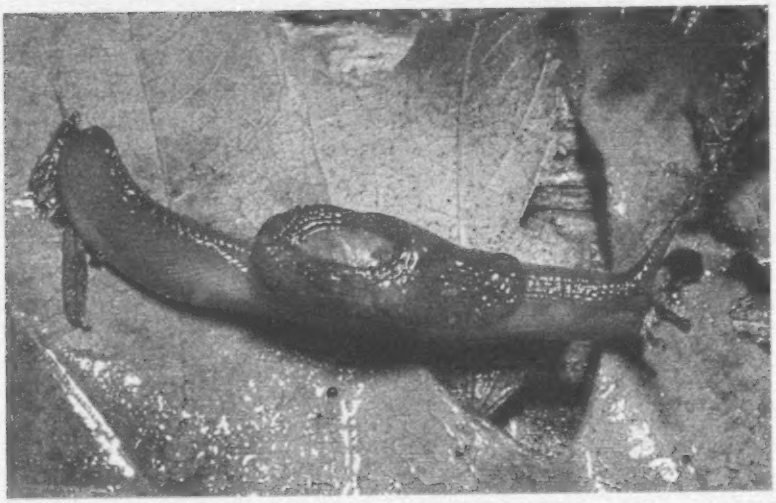
COSEWIC
Assessment and Status Report

on the

Dromedary Jumping-slug
Hemphillia dromedarius

in Canada



THREATENED
2014

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC
Assessment Summary

Assessment Summary – May 2014

Common name
Dromedary Jumping-slug

Scientific name
Hemphillia dromedarius

Status
Threatened

Reason for designation
This relatively large slug is a member of a small group of slugs that are found globally only in western North America. In Canada, despite a great deal of searching, this species is known from fewer than 20 sites on southern Vancouver Island. There, it is restricted to moist, older-growth (>80 years old) forests. Populations are invariably small, and are fragmented by intervening logged areas and by the species' poor dispersal ability. Threats include further loss and fragmentation from forestry and the increased frequency and severity of droughts associated with climate change.

Occurrence
British Columbia

Status history
Designated Threatened in May 2003. Status re-examined and confirmed in May 2014.

COSEWIC
Executive Summary

Dromedary Jumping-slug
Hemphillia dromedarius

Wildlife Species Description and Significance

Jumping-slugs (genus *Hemphillia*) are a small group of forest-dwelling slugs endemic to western North America. Of the seven recognized species, three occur in Canada (Dromedary Jumping-slug, *H. dromedarius*; Warty Jumping-slug, *H. glandulosa*; Pale Jumping-slug, *H. camelus*). The Dromedary Jumping-slug is a relatively large (ca. 60 mm long) slug with a distinctive appearance: the visceral pouch is elevated into a pronounced hump and a part of the internal shell plate is visible through a slit in the mantle. The tail is laterally compressed, keeled, and tipped with a horn-like protuberance (caudal horn). The predominant colour is grey with darker mottling; the sole of the foot is often bright yellow or orange. Because of its distinct appearance and remarkable escape behaviour, the Dromedary Jumping-slug might be useful as a flagship species for promoting awareness and conservation of forest floor invertebrates and their habitats.

Distribution

The geographic range of the Dromedary Jumping-slug extends south from Vancouver Island, British Columbia, to the Cascade Range and Olympic Peninsula in western Washington and into northwestern Oregon. In British Columbia, the species is known from 19 sites on southern and western Vancouver Island. On the west coast of the island, it has been found within an approximately 130 km stretch of lowland coastal forest from near Port Renfrew to Tofino. Away from the coast, scattered records exist from high-elevation (700 – 1200 m) forests on mountains in the southern interior of the island. The species' presence in Canada was confirmed only recently, and all records are from 1999 – 2008; an early, unconfirmed record of a large jumping-slug from Vancouver Island was most likely of this species.

Habitat

On Vancouver Island, this slug occurs in moist, older coniferous forests. Key habitat features are high humidity and a complex forest floor structure created by layers of decaying wood, root masses and crevices, such as is present in old-growth forests. The presence of coarse woody debris is probably important for refuges and oviposition sites.

Biology

The ecology and life history of the Dromedary Jumping-slug are poorly known. The species is hermaphroditic and egg-laying (oviparous). Clutch size is 50 – 60 eggs, which are deposited in moist, rotting wood. Individuals live more than 1 year. The anti-predator behaviour of jumping-slugs is unique and consists of writhing and leaping in response to disturbance. The dispersal ability of the Dromedary Jumping-slug is probably poor, as reflected by the scattered distribution pattern of the species.

Population Sizes and Trends

Surveys for the Dromedary Jumping-slug have focused on obtaining information on distribution rather than on abundance, and little is known of population sizes or trends in Canada. At the scattered sites where it occurs, the species appears to exist at very low densities. Continuing population declines are inferred and suspected based on shrinking old-growth forest habitats within the species' range.

Threats and Limiting Factors

The low number of populations and scattered distribution pattern within its Canadian range render the species vulnerable to habitat alteration and stochastic events, such as droughts or wildfires. Because of the association of the Dromedary Jumping-slug with older forests, loss and fragmentation of habitats by logging are of particular concern. Increased frequency and intensity of droughts associated with climate change are expected to deteriorate habitats and exacerbate effects of logging and other disturbances. Degradation of microhabitats and concentration of invertebrate predators in small habitat patches within fragmented landscapes are expected to be detrimental to the survival of populations of this species.

Protection, Status, and Ranks

The Dromedary Jumping-slug is federally listed as Threatened on Schedule 1 under the *Species at Risk Act*. In British Columbia, it is on the red-list of species at risk. As part of the federal recovery strategy for the species, Critical Habitat polygons have been drafted for the species at 15 occupied sites. If approved, habitat within the polygons under federal jurisdiction would receive protection from activities identified as damaging. Along the west coast of Vancouver Island, several records are from the Pacific Rim National Park Reserve, which appears to act as a stronghold and an important refuge for the species. Most records from the interior of Vancouver Island are from unprotected forestry lands.

TECHNICAL SUMMARY

Hemphillia dromedarius
Dromedary Jumping-slug Limace-sauteuse dromadaire
Range of occurrence in Canada (province/territory/ocean): British Columbia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2008) is being used)	>1 yr
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? - Inferred and projected decline based on habitat trends (forestry) and climate change (increased intensity and frequency of droughts)	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. - Inferred and suspected decrease based on habitat trends	≥10%
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. - Suspected decrease based on habitat trends and threats calculator results	≥10%
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. - Inferred and suspected decrease based on habitat trends and threats calculator results	≥10%
Are the causes of the decline clearly reversible and understood and ceased? - Partially understood, not clearly reversible and not ceased	No
Are there extreme fluctuations in number of mature individuals?	Unknown, probably not

Extent and Occupancy Information

Estimated extent of occurrence	6,695 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value). - Discrete value based on 18 grid cells. If the calculations include a continuous IAO from Port Renfrew to Tofino along the west coast of Vancouver Island, then the IAO is 400 km^2. It is extremely unlikely that IAO will exceed 2000 km^2 (500 grids), even if further searches reveal additional sites.	72 km²

Is the population severely fragmented? On the west coast of Vancouver Island, extensive logging and land clearing has resulted in a narrow or discontinuous band of mature forest habitat along the coast and in the interior of the island, where populations are isolated on mountain-top forest remnants due to extensive logging of surrounding areas. Viability of more than half of the known occupied sites was assessed as low based on threats, landscape context, aerial photographs, and knowledge of habitat on the ground.	Yes
Number of locations* - Based on threats at known occupied sites; lowest value if climate change and severe weather (droughts) are considered most important threat; highest value if threats are specific to each site or group of sites under same land use and ownership/management	7 – 13; most likely >10
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence? - Inferred and projected decline is likely based on habitat trends but beyond the 10 year time-frame considered here. If mountain populations in the interior of Vancouver Island are lost, there would be a significant reduction in EO over the next several decades.	Probably not
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? - Inferred and projected decline based on habitat trends	Yes
Is there an [observed, inferred, or projected] continuing decline in number of populations? Inferred and projected decline based on habitat trends	Yes
Is there an [observed, inferred, or projected] continuing decline in number of locations*? Inferred decline if mountain-top populations are lost due to logging and isolation effects.	Yes
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? - Yes, observed, inferred, and projected, primarily due to logging; projected due to climate change and severe weather	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	No. of Mature Individuals
Shawnigan (unnamed mountain)	Unknown
Mt. Arrowsmith	Unknown
Mt. Brenton	Unknown
Mt. Hooper	Unknown
Pacific Rim populations along the west coast of Vancouver Island	Unknown
Total	Unknown

*See Definitions and Abbreviations on the COSEWIC website and IUCN 2010 for more information on this term.

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not done

Threats (actual or imminent, to populations or habitats)

Habitat loss, degradation, and fragmentation from logging; climate change and severe weather, mainly droughts

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Washington State	S3S4 (vulnerable/apparently secure)
Is immigration known or possible? - Impossible based on current known distribution; if the species is discovered on mainland BC, where there is a record from near the international border in Washington, immigration would be possible but slow and limited to the areas in the immediate vicinity of the border.	Maybe
Would immigrants be adapted to survive in Canada?	Possibly
Is there sufficient habitat for immigrants in Canada?	Probably not
Is rescue from outside populations likely?	No

Data-Sensitive Species

Is this a data-sensitive species?	No

Status History

Designated Threatened in May 2003. Status re-examined and confirmed in May 2014.

Additional Sources of Information:
Provincial Recovery Strategy (BC Invertebrates Recovery Team 2008)
Federal Recovery Strategy, draft (Parks Canada Agency 2012)

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric code:** B1ab(iii)+2ab(iii)
Reasons for designation: This relatively large slug is a member of a small group of slugs that are found globally only in western North America. In Canada, despite a great deal of searching, this species is known from fewer than 20 sites on southern Vancouver Island. There, it is restricted to moist, older-growth (>80 years old) forests. Populations are invariably small, and are fragmented by intervening logged areas and by the species' poor dispersal ability. Threats include further loss and fragmentation from forestry and the increased frequency and severity of droughts associated with climate change.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. The number of mature individuals is unknown and while there is a suspected continuing decline in number of individuals based on habitat trends and results of the threats calculator, the magnitude of the decline is most likely below the threshold of 30% occurring within the next 10 years.

Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened B1ab(iii)+2ab(iii) because the EO (6,695 km^2) is below the threshold for TH (< 20,000 km^2) and, although the known IAO (72 km^2 discrete, 400 km^2 continuous along west coast) is below the threshold for EN (< 500 km^2), it may be in fact larger, but it is unlikely to exceed the limit for TH (2000 km^2). The population is severely fragmented, and there is an observed, inferred, projected continuing decline in area, extent and quality of habitat. There are most likely more than 10 locations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is unknown.
Criterion D (Very Small or Restricted Population): Not applicable. D1 is not applicable as the number of mature individuals is unknown. D2 TH also is not applicable because both the IAO and number of locations exceed the typical thresholds.
Criterion E (Quantitative Analysis): Not applicable as analyses have not been done.

PREFACE

This report is an update of the previous COSEWIC status report for the Dromedary Jumping-slug (COSEWIC 2003). Since then, additional surveys for terrestrial gastropods have been conducted in different parts of British Columbia, including surveys specifically targeting this species on Vancouver Island. New distribution records have expanded the known area of occupancy and the extent of occurrence, but the species has not been found beyond the southern third of Vancouver Island.

A provincial recovery strategy has been completed (BC Invertebrates Recovery Team 2008), and a federal recovery strategy has been drafted (Parks Canada Agency 2012). The latter document contains a partial identification of critical habitat for the species.

This species was not selected to go through the formal Aboriginal Traditional Knowledge (ATK) gathering process by the COSEWIC ATK Subcommittee (Jones pers. comm. 2012).

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2014)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Dromedary Jumping-slug

Hemphillia dromedarius

in Canada

2014

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Jumping-slugs (genus *Hemphillia* Bland and Binney 1872) are currently within the large, cosmopolitan family Arionidae, subfamily Ariolimacinae (Pilsbry 1948). An alternative classification by Bouchet and Rocroi (2005) raises all arionid subfamilies to full family status, but genetic studies do not support the monophyly of either Arionidae or Ariolimacinae/Ariolimacidae (Backeljau pers. comm. 2011).The genus *Hemphillia* is endemic to western North America, where seven species are currently recognized (Turgeon *et al.* 1998): *H. glandulosa* Bland and Binney, 1872; *H. camelus* Pilsbry and Vanatta, 1897; *H. danielsi* Vanatta 1914; *H. malonei* Pilsbry 1917; *H. burringtoni* Pilsbry 1948; *H. dromedarius* Branson 1972; and *H. pantherina* Branson 1975. Preliminary genetic analysis, based on two mitochondrial genes (COI and 16S), suggest that the genus *Hemphillia* is not monophyletic (Wilke 2004). Additional, unrecognized species may exist (Kelley *et al.* 1999).

Three species are known from Canada: Warty Jumping-slug (*H. glandulosa;* COSEWIC status: Special Concern); Pale Jumping-slug (*H. camelus*; COSEWIC Status: not assessed); and Dromedary Jumping-slug (*H. dromedarius*). *Hemphillia dromedarius* was described relatively recently based on material from Washington State, United States (type locality: Staircase Falls, Olympic National Park; Branson 1972). All museum specimens of the sympatric *H. glandulosa* from British Columbia (BC) that are known to date from after 1972 do not contain misidentified specimens (COSEWIC 2003). No specimens of any *Hemphillia* species from BC were found in collections in the US. No subspecies of *H. dromedarius* are recognized.

The current classification is as follows:

Phylum Mollusca
Class Gastropoda
Subclass Pulmonata
Order Stylommatophora
Suborder Arionoidea
Family Arionidae
Subfamily Binneyinae
Genus *Hemphillia*
Species *Hemphillia dromedarius*

Morphological Description

Branson (1972) provided a description and photographs of *H. dromedarius*. Ovaska *et al.* (2002) provided a redescription and diagram of the anatomy of the reproductive system, which is typically important for the identification of slugs (Kerney and Cameron 1979; Tompa 1984).

Hemphillia dromedarius is a relatively large slug (total length to approximately 60 mm when extended; Figure 1). As in other members of the genus *Hemphillia*, the visceral pouch is elevated into a pronounced hump and a part of the internal shell plate is visible through a slit in the mantle. The tail is laterally compressed, keeled, and tipped with a fleshy horn-like protuberance, termed the caudal horn. The predominant colour of the mantle and foot is typically grey with cream-coloured mottling on the sides; the sole of the foot is pale yellow, orange-yellow, or cream-coloured.

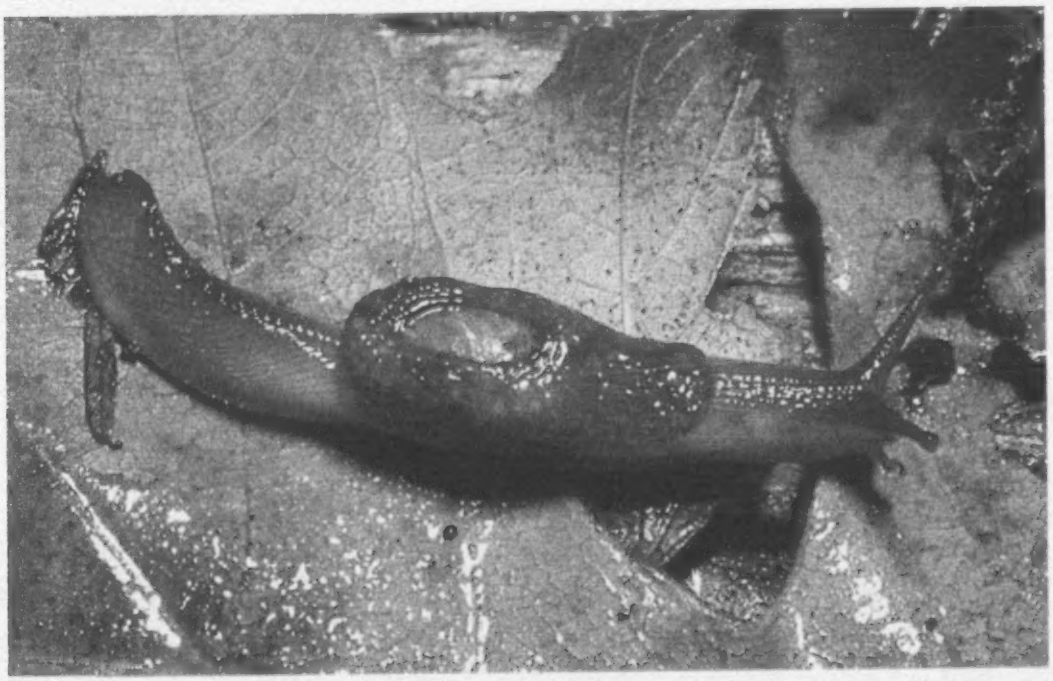

Figure 1. The Dromedary Jumping-slug, *Hemphillia dromedarius*, from Vancouver Island. Photograph by K. Ovaska. The slug measured about 60 mm when extended.

Jumping-slugs are distinct in appearance and unlikely to be confused with members of other genera, but *H. dromedarius* can be confused with other species of the genus. In BC, larger body size and lack of conical papillae on the mantle distinguish it from the sympatric *H. glandulosa*. *Hemphillia camelus* is approximately the same size as *H. dromedarius* but lacks a prominent caudal horn. In BC the two species are allopatric; *H. camelus* occurs east of the Coast Mountains, whereas *H. dromedarius* is known only from Vancouver Island. Features of the distal reproductive system, particularly the penis and associated structures, can be used to confirm species identification. A diagram of the distal reproductive system of a specimen from BC is shown in Figure 2.

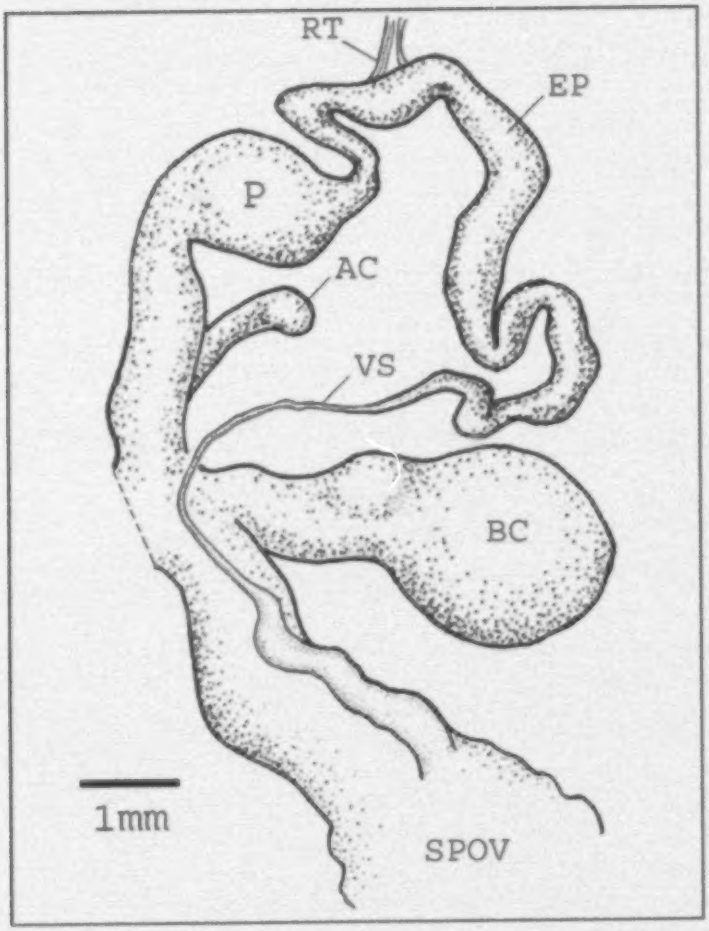

Figure 2. Distal genitalia of *Hemphillia dromedarius* from Vancouver Island (RBCM 001-00283-001). Drawing by K. Ovaska. AC – penial accessory sac; BC – bursa copulatrix (spermatheca); EP – epiphallus; P – penis; RT – penial retractor; SPOV – spermoviduct; VS – vas deferens

Population Spatial Structure and Variability

Population structure of *H. dromedarius* has not been studied, and no genetic studies are available. The dispersal ability of the species is probably poor, as reflected by its scattered distribution, which might be a result of isolation of demes through habitat fragmentation.

Based on the availability of suitable habitat, the distribution of *H. dromedarius* along the west coast of Vancouver Island is probably more continuous than in the interior of the island, where the species is known only from high-elevation forests (see **Canadian Range**). These mountain populations are isolated from each other due to drier lowland forest types and extensive logging that have created habitat discontinuities. On the west coast of Vancouver Island, where the species occurs within

an approximately 130 km stretch of coastal forest from near Port Renfrew to Tofino, natural barriers created by the Strait of Juan de Fuca, Nitinat River, and Barkley Sound have fragmented populations. Drier forest types, including young forest stands resulting from logging, probably curtail connectivity of subpopulations from the coast to inland areas.

Designatable Units

In Canada, *H. dromedarius* is known only from Vancouver Island and from one COSEWIC national ecological area (Pacific ecological area). No information is available on morphological, anatomical, ecological, or genetic differences among populations that would warrant the treatment of the species as more than one designatable unit.

Special Significance

Hemphillia dromedarius is one of relatively few native slugs in west coast forests in Canada, and it provides an important contribution to the native biodiversity of these forests. The ecological importance of *H. dromedarius* is unknown. Other arionid slugs from the west coast of North America, such as the Pacific Bananaslug, *Ariolimax columbianus* and Blue-grey Taildropper, *Prophysaon coeruleum*, appear to play a role as a dispersal agent for fungal spores (Richter 1980; McGraw *et al.* 2002), including those fungi that form mycorrhizal associations with tree roots. However, without accurate information on the diet of *H. dromedarius,* whether this species plays a similar ecological role remains speculative.

Because of their distinct appearance and remarkable escape behaviour, jumping-slugs typically generate interest and have appeal to the general public as charismatic invertebrates. Members of this genus, including *H. dromedarius*, could be useful as flagship species for promoting awareness and conservation of forest floor invertebrates and their habitats.

DISTRIBUTION

Global Range

Globally, *H. dromedarius* occurs within a relatively small area in extreme southwestern BC and the Pacific Northwest of the US. Its distribution extends southward from Vancouver Island to the Olympic and Cascade Mountains of western Washington and into northwestern Oregon (Figure 3). NatureServe (2012) gives the global range extent for *H. dromedarius* as 5000 – 20,000 km^2, and the number of occurrences as 21 – 80 (information last updated in 2005).

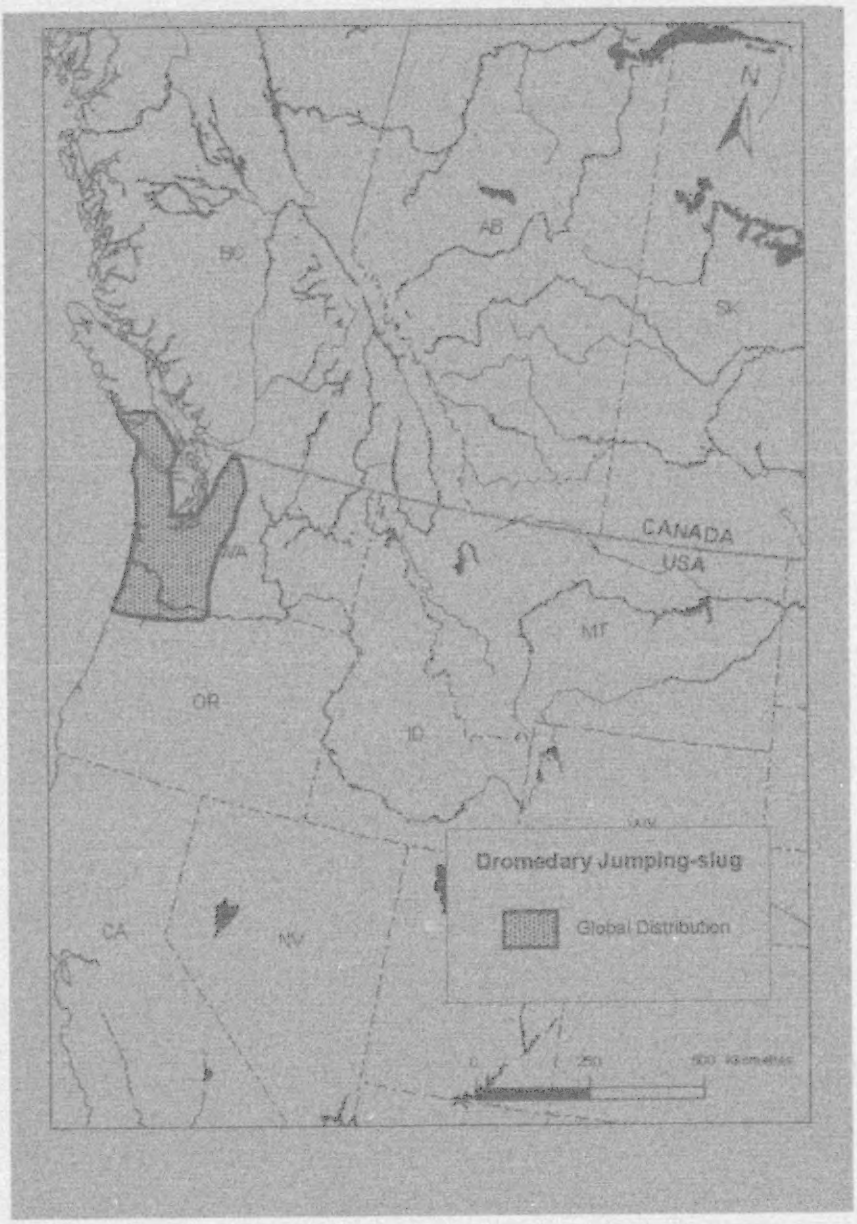

Figure 3. North American distribution of *Hemphillia dromedarius*, based on Branson (1972, 1977, 1980), Burke (2013), and Canadian records. Map prepared by Biolinx Environmental Research Ltd. (L. Sopuck).

Most of the records in the US are from Washington State, where the species appears to be fairly widespread within the Cascade Range and the Olympic Peninsula. It has been collected from several national parks (Olympic, Northern Cascades, Snoqualmie, Wenatchee, Mt. Baker, and Mt. Rainier) (Branson 1972, 1977, 1980; Ovaska *et al.* 2002). The easternmost records are from the east slope of the Cascade Range (Ovaska *et al.* 2002). The species has only recently been confirmed from

Oregon, where it occurs in the extreme northwest (Leonard pers. comm. 2012; Burke 2013). Some of the early records from western Washington for *H. malonei* reported by Pilsbry (1948), and not dissected by him due to unavailability of specimens, may belong to this species. The ranges of the two species overlap broadly in western Washington, but they can be distinguished relatively easily based on external appearance and reproductive anatomy.

The species has been reported from near sea level to elevations of 1200 m in BC (Table 1). In Washington, the species has been reported from elevations of 238 m (780 feet) to 1436 m (4710 feet; Branson 1972); most reported localities are from elevations above 700 m (Branson 1972, 1977, 1980; Ovaska *et al.* 2002).

Table 1. Summary of Canadian distribution records of *Hemphillia dromedarius*. All sites are on Vancouver Island, BC; sites are organized geographically, with the interior sites first, followed by the coastal sites from south to north. All records obtained after 2001 are new since the previous COSEWIC status report.

Site ID	Year (month)	Site name	Land jurisdiction	Elev (m)	No. of slugs	Sources
1	1999 (Oct)	7 km NW of Shawnigan Lake	Private forestry	700	1	Ovaska and Sopuck 2000; Ovaska *et al.* 2002
2	2006 (Sept)	Mount Arrowsmith Massif, N slope of Mt. Cokely	Crown land	1200	1	Ovaska and Sopuck 2007b
3	2008 (Sept)	Mt. Arrowsmith - near McBey Creek	Mt Arrowsmith Regional Park	993	1	Biolinx Environmental Research Ltd. (2008)
4	2001 (Aug)	Mt. Brenton, near Holyoak Lake, ca. 18 km W of Chemainus	Crown forestry land	1060	2	Ovaska *et al.* 2001; Ovaska *et al.* 2002
5	2001 (Sept)	Mt. Hooper (near summit), ca. 20 km NW of Youbou	Private forestry	850	2	Ovaska *et al.* 2001; Ovaska *et al.* 2002
6	2000 (Apr) 2001 (June)	Juan de Fuca Provincial Park: Loss Creek, near HWY14, SE of Port Renfrew	BC Parks	140	3	Ovaska *et al.* 2001; Ovaska *et al.* 2002
7	2004	Pacific Rim National Park Reserve, West Coast Trail unit: Thrasher Cove, NW of Port Renfrew	Parks Canada; Federal	80	8	Ovaska and Sopuck 2005a
8	2004 (July)	Pacific Rim National Park Reserve, West Coast Trail unit: Clo-oose	Parks Canada; Federal	10	1	Ovaska and Sopuck 2005a
9	2006 (Sept)	Pacific Rim National Park Reserve, West Coast Trail unit: Keeha Beach Trail, near Cape Beale	Parks Canada; Federal	20	1	Ovaska and Sopuck 2007a
10	2000 (July)	Bamfield, W of Woods End Landing	Private rural	30	1	Ovaska *et al.* 2001; Ovaska *et al.* 2002
11	2007 (Aug)	Bamfield Marine Station	Private	<50	1	Beasley pers. comm. 2008
12	2006 (Nov)	Willowbrae, Ucluelet, adjacent to Pacific Rim National Park Reserve, Long Beach unit	Indian Reserve lands (Ucluelet First Nation)	30	1	Ovaska and Sopuck 2007a
13	2001 (Nov)	Indian Creek, ca. 9 km N of Ucluelet on Kennedy Flats	Crown land (TFL 54)	45	1	Ovaska *et al.* 2001; Ovaska *et al.* 2002
14	2003 (Nov) 2004 (May)	Pacific Rim National Park Reserve (SE of Goldmine Trail)	Parks Canada; Federal	25	3	Ovaska and Sopuck 2005a
15	2003 (Sept) 2004 (May)	Pacific Rim National Park Reserve (Rainforest A Trail)	Parks Canada; Federal	40	5	Ovaska and Sopuck 2005a

Site ID	Year (month)	Site name	Land jurisdiction	Elev (m)	No. of slugs	Sources
16	2006 (July)	Pacific Rim National Park Reserve (Rainforest B Trail)	Parks Canada; Federal	30	1	Ovaska and Sopuck 2007a
17	2007 (June)	Highway SE of the Pacific Rim National Park Reserve border	Crown land (Quarry?)	40	1	Beasley pers. comm. 2008
18	2007 (June)	Highway right at the Pacific Rim National Park Reserve border	Parks Canada; Federal	40	1	Beasley pers. comm. 2008
19	2007	Tyhistanis, near Pacific Rim National Park Reserve	Indian Reserve lands (Tla-o-qui-aht First Nation)	N/A	1	Observation by Martin Gebauer (Vennesland pers. comm. 2012)

Canadian Range

The Canadian distribution of *H. dromedarius* is confined to the southern third of Vancouver Island, BC (Figure 4). The species' presence was confirmed only recently (Ovaska *et al.* 2002), but an early, unconfirmed record (Hanham 1926) exists of a large jumping-slug from Vancouver Island, most likely of this species. On 2 July 1916, Hanham (1926: 143) found two large jumping-slugs "under a log on the border of a good-sized lake, on Mt. Brenton, Vancouver Island." Both specimens disintegrated before they could be preserved but several years later were identified as *H. malonei* by Walter J. Eyerdam (Seattle, Washington), based on Hanham's recollection of the animals' colour. Later authors (Pilsbry 1948; Kozloff and Vance 1958) questioned this record, and its identity remained enigmatic until specimens of *H. dromedarius* were found on Mt. Brenton in the autumn of 2001 (Ovaska *et al.* 2001).

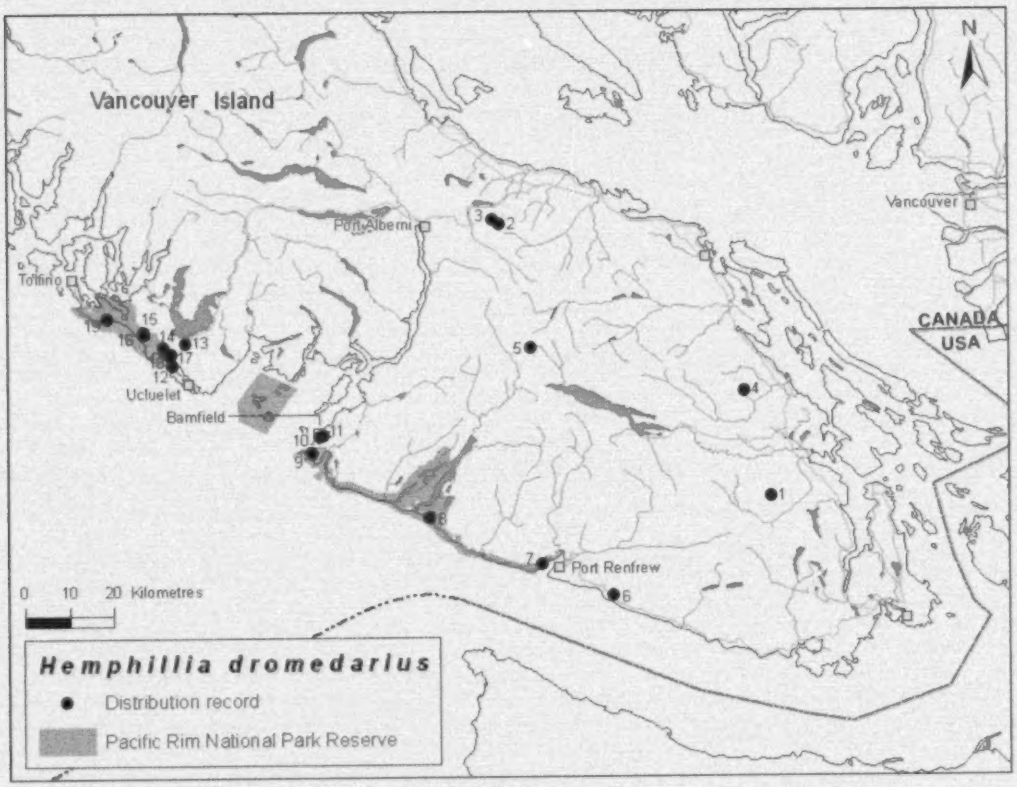

Figure 4. Canadian distribution of *Hemphillia dromedarius* on Vancouver Island, BC.

Survey efforts since the previous status report (COSEWIC 2003) have increased the number of known sites on Vancouver Island from six to 19 (Table 1). Most records are from along the west coast of the island, from Port Renfrew northward to near Tofino. Away from the west coast, there are isolated records from high-elevation (700 – 1200 m) forests on mountains in the southern interior of the island, from near Duncan northward to Port Alberni.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EO) of the Dromedary Jumping-slug in Canada is 6,695 km^2, based on the minimum convex polygon method (calculations by Jenny Wu, COSEWIC Secretariat). This value represents an increase of 68% from the previously reported value of 3,985 km^2 (COSEWIC 2003). The increase is mainly due to the expansion of the known range to the northeast with the discovery of the species on Mt. Arrowsmith Massif, near Port Alberni.

The total area of draft Critical Habitat that has been identified is 254 ha (2.54 km^2) in 15 polygons (Parks Canada Agency 2012; Table 2), corresponding roughly to the known area of occupancy. The index of the area of occupancy (IAO) is 72 km^2, based on 18 grids of 4 km^2 (calculations by Jenny Wu, COSEWIC Secretariat). This value represents an increase of 200% from the previous IAO of 24 km^2, which was based on six occupied sites in 2003 (IAO was not presented in COSEWIC 2003). If the calculations include a continuous IAO from Port Renfrew to Tofino along the west coast of Vancouver Island, then the IAO is 400 km^2. This value is most likely an underestimate, because other undocumented sites may well exist. Suitable unsurveyed habitat exists especially along the west coast of Vancouver Island (Appendix 1). However, it is extremely unlikely that the IAO will exceed 2000 km^2 (500 grids), even if further search effort reveals additional sites, given the limited EO, patchy distribution, and specific habitat requirements of this species.

Table 2. Habitat and viability assessment for sites where *Hemphillia dromedarius* has been found on Vancouver Island, BC. Sites are organized geographically, with the interior sites first, followed by the coastal sites from south to north. All records obtained after 2001 are new since the previous COSEWIC status report. Critical habitat polygons were determined by Parks Canada Agency (2012).

Site ID	Year (month)	Site name	BEC zone[A]	BEC sub-zone[A,A]	Habitat description	Critical habitat polygon (ha)	Ecotype[B]	Structural stage[BB]	Viability potential (high – low)
1	1999 (Oct)	7 km NW of Shawnigan Lake	CWH	mm	Remnant high elevation old-growth coniferous forest	21	HD, AP	5, 6, 7	Low; extensive logging, on private land; forest remnant
2	2006 (Sept)	Mount Arrowsmith Massif, N slope of Mt. Cokely	MH	mm	Remnant stunted high elevation old-growth coniferous forest	3	MB	7	Low; harsh conditions; soil compacted by abandoned ski development; climate change is threat; lower elevations surrounding site are logged
3	2008 (Sept)	Mt. Arrowsmith Massif, near McBey Creek	MH	mm	High elevation old-growth coniferous forest	20	HS	7	Low; remnant forest patch; extensive logging in area
4	2001 (Aug)	Mt. Brenton, near Holyoak Lake, ca. 18 km W of Chemainus	MH	mm	Remnant high elevation old-growth coniferous forest	3	MB	6	Low; remnant forest patch surrounded by logging and dam/reservoir; ATV use in forest patch
5	2001 (Sept)	Mt. Hooper (near summit), ca. 20 km NW of Youbou	CWH	mm	Remnant high elevation coniferous forest	20	MB, YS, MT	7	Moderate; private forestry lands, but larger patches of old growth remain on this and adjacent peaks; logging and climate change are threats
6	2000 (Apr) 2001 (June)	Juan de Fuca Provincial Park: Loss Creek, near HWY14, SE of Port Renfrew	CWH	vm	Strip of old-growth coniferous forest along river	20	HD, AB, AD	5, 6, 7	Low; small remnant forest patch; extensive logging in surrounding landscape
7	2004	Pacific Rim National Park Reserve, West Coast Trail unit: Thrasher Cove, NW of Port Renfrew	CWH	vm	Old-growth cedar–hemlock coastal forest near Thrasher Cove NW of Port Renfrew on West Coast Trail	20	AB	7	Moderate; narrow strip of habitat along the coast with logging right up to park border to the east
8	2004 (July)	Pacific Rim National Park Reserve, West Coast Trail unit: Clo-oose	CWH	vh	Older second-growth cedar–hemlock coastal forest	20	HS	6, 7	High; relatively large block of suitable forest within protected area
9	2006 (Sept)	Pacific Rim National Park Reserve, West Coast Trail unit: Keeha Beach Trail, near Cape Beale	CWH	vh	Old-growth cedar–hemlock coastal forest	20	HS	7	High; relatively large block of old growth in protected area

Site ID	Year (month)	Site name	BEC zone^	BEC sub-zone^^	Habitat description	Critical habitat polygon (ha)	Ecotype*	Structural stage**	Viability potential (high – low)
10	2000 (July)	Bamfield, W of Woods End Landing	CWH	vh	Mixed old- and second-growth cedar–hemlock coastal forest	20	HS	4, 5, 6, 7	Low; housing developments and logging
11	2007 (Aug)	Bamfield Marine Station	CWH	N/A	Door of trailer; unsure where the slug came from	N/A	N/A	N/A	Low; highly fragmented habitat close to town with development a threat
12	2006 (Nov)	Willowbrae, Ucluelet, adjacent to Pacific Rim National Park Reserve, Long Beach unit	CWH	vh	Old-growth cedar–hemlock coastal forest along	20	HS	7	Moderate; ongoing resort developments but adjacent to protected area
13	2001 (Nov)	Indian Creek, ca. 9 km N of Ucluelet on Kennedy Flats	CWH	vh	Old-growth cedar–hemlock coastal forest	18	HS, SD	6	Low; extensive logging in area; occupied patch has been logged recently
14	2003 (Nov) 2004 (May)	Pacific Rim National Park Reserve (SE of Goldmine Trail)	CWH	vh	Old-growth cedar–hemlock coastal forest southeast of Goldmine Trail	20	HS	6, 7	High; continuous old-growth and boggy forest within protected area
15	2003 (Sept) 2004 (May)	Pacific Rim National Park Reserve (Rainforest A Trail)	CWH	vh	Old-growth cedar–hemlock coastal forest along Rainforest A Trail	6	HS	7	Low; small patch of suitable forest between HWY and extensive clearcuts
16	2006 (July)	Pacific Rim National Park Reserve (Rainforest B Trail)	CWH	vh	Old-growth cedar–hemlock coastal forest along Rainforest B Trail	22	HS, SD	7	High; continuous area of moist old-growth forest
17	2007 (June)	Highway SE of the Pacific Rim National Park Reserve border	CWH	vh	On inland lane of highway; 2nd growth forest with old-growth legacy of large downed trees.	N/A	N/A	N/A	Low; outside of park, influenced by industrial developments and land clearing
18	2007 (June)	Highway right at the Pacific Rim National Park Reserve border	CWH	vh	Seaside lane of the highway; 2nd growth forest with old-growth legacy of large downed trees.	N/A	N/A	N/A	Moderate; on park boundary and near continuous forest habitat
19	2007	Tyhistanis, near Pacific Rim National Park Reserve	CWH	vh	Old-growth forest near Schooner Trail Pacific Rim National Park Reserve	N/A	N/A	N/A	Low; airport, HWY, and expanding housing development.

^ Biogeoclimatic zones: CWH - Coastal Western Hemlock; MH - Mountain Hemlock

^^ Biogeoclimatic subzones: mm - moist maritime; vh - very wet hypermaritime; vm - very wet maritime

*Forest ecotypes: HD = Western Hemlock/Amabalis Fir-Deer Fern; AP = Western Hemlock/Amabalis Fir-Pipecleaner Moss; AB = Western Hemlock/Amabalis Fir-blueberry/Salal; AD = Amabalis Fir / Sitka Spruce - Devil's Club; HS = Western Redcedar/Western Hemlock-Salal; MB = Mountain Hemlock/Amabalis Fir-blueberry; SD = Western Redcedar/Sitka Spruce-Devil's Club; YS = Mountain Hemlock/Yellow Cedar - Sphagnum; MT = Amabalis Fir / Mountain Hemlock - Twistedstalk; (RIC 1998).

**Structural stages of dominant ecotype polygons, as follows: 4, forest < 40 years old; 5, forest 40-80 years old; 6, forest 80-250 years old; 7, forest >250 years old (RIC 1998).

Search Effort

Numerous surveys have been conducted for terrestrial gastropods in southwestern BC from 1984 – 2012 (Table 3; see Figure 5 for survey coverage). Several surveys since the previous status report have specifically targeted potential habitats of *H. dromedarius* (Ovaska and Sopuck 2005a, 2007a,b). Overall, the areas receiving the highest survey coverage include the southeastern and southwestern coastal areas of Vancouver Island, northeastern Vancouver Island, Sunshine Coast, Lower Fraser Valley, and Chilliwack Valley. There are gaps in survey coverage on northwestern Vancouver Island, portions of the interior mountains of Vancouver Island and the BC mainland north of Powell River. All of these areas have limited or no road access. It is possible that the species occurs along the west coast of Vancouver Island north of

Tofino in habitats similar to those used by the species in Pacific Rim National Park Reserve, although a survey of the Gold River area in 2001 and on the Brooks Peninsula in 2012 failed to find the species. It is also possible that the slug occurs on additional mountain top sites in the Island's interior, including unsurveyed areas to the northwest of their known range (see Appendix 1 for preliminary habitat suitability mapping by Wilson and Craig 2013). The slug was not found during intensive, multi-year surveys on northeastern Vancouver Island (from Campbell River to Port McNeill) and the Powell River area on the Sunshine Coast (Ovaska and Sopuck 2005b, 2008), suggesting the species may be absent or very patchily distributed to the northeast of their known range on Vancouver Island. One locality of *H. dromedarius* in Washington State is only about 10 km south of the Canadian border in the Cascade Mountain range (Branson 1980). However, despite considerable survey effort in the Chilliwack River valley of the BC mainland directly north of Branson's (1980) locality in Washington State, the species has not been found.

Table 3. Summary of search effort for terrestrial gastropods on Vancouver Island, Lower Mainland (including Chilliwack Valley and Hope), and Sunshine Coast of BC, 1984-2012.

Year (season)	Area & number of sites	Survey type*	Total search time or effort; no. of ACOs*	# of ACO checks	Source**
1984	11 sites (23 plots) on Vancouver Island; 7 sites (15 plots) on Lower Mainland and Chilliwack Valley	Searches of habitat plots (area constrained)	not available	n/a	Cameron (1986)
1990-2012	Approx. 262 sites distributed over Vancouver Island, Gulf Islands, Sunshine Coast, Lower Mainland and Chilliwack Valley	Visual searches of natural cover	not available	n/a	R. Forsyth pers. comm. 2012
2000-2001 (spring & fall)	104 sites widely distributed over Vancouver Island; 27 on Lower Mainland, and 11 in Chilliwack Valley	Time-constrained surveys	196.6 person-hrs	n/a	Ovaska *et al.*, surveys for Environment Canada (Endangered Species Recovery Fund)
2002 (spring & fall)	3 sites (56 transects) on DND lands on the southern tip of Vancouver Island	Transect surveys	71.6 person-hrs	n/a	Ovaska and Sopuck, surveys for Department of National Defence
2003 (spring)	30 sites on south and southeast Vancouver Island, 22 sites on Lower Mainland	Time-constrained surveys	19.25 person-hrs	n/a	Ovaska and Sopuck, surveys for BC Min. Water, Land, & Air Prot.
2003-2004 (spring & fall)	39 sites on southern tip of Vancouver Island, 4 sites on Lower Mainland	Time-constrained daytime & night surveys; inspection of ACOs	47.4 person-hrs and 260 ACOs on Van. Island and 7.9 person-hrs on Lower Mainland	880 on Van. Island	Ovaska *et al.*, surveys for Environment Canada (Endangered Species Recovery Fund)

Year (season)	Area & number of sites	Survey type*	Total search time or effort; no. of ACOs*	# of ACO checks	Source**
2003-2004 (spring & fall)	35 sites in Pacific Rim National Park Reserve (2003-2004) and Gulf Islands National Park Reserve (2004)	Time-constrained daytime & night surveys; inspection of ACOs	119.7 person-hrs and 240 ACOs (Pacific Rim); 44.8 person-hrs and 80 ACOs (Gulf Islands)	1040 on Van. Island; 160 in Gulf Islands	Ovaska and Sopuck, surveys for Parks Canada
2003-2004 (spring & fall)	2 sites on Lower Mainland (Aldergrove, Matsqui), 1 site on southern Vancouver Island (Colwood)	Time-constrained surveys	53.9 person-hrs on Lower Mainland; 21.5 person-hrs on southern Vancouver Island	n/a	Ovaska and Sopuck, surveys for Department of National Defence
2004-2005 (spring & fall)	2 sites on Lower Mainland (Aldergrove and Matsqui)	Time-constrained surveys	93.1 person-hrs	n/a	Ovaska and Sopuck, surveys for Department of National Defence
2004-2005 (spring & fall)	30 sites on Lower Mainland and Chilliwack Valley	Time-constrained surveys	57.9 person-hrs	n/a	Ovaska and Sopuck, surveys for BC Min. Water, Land, & Air Prot.
1999-2001 (spring & fall)	9 sites on southeastern Vancouver Island in 1999 & 2001; 11 sites on northeastern Vancouver Island in 2000 and 2001; 2 sites on southwestern Vancouver Island in 2001	Point, transect and quadrat surveys, litter samples, inspection of ACOs	26 point searches, 562 quadrats, 50 transects, 615 ACOs	Approx. 1,475	Ovaska and Sopuck, surveys for Weyerhaeuser Company Limited
2001-2007 (spring and fall)	Experimental Pre and Post-logging surveys at 5 sites (3 on northern Vancouver Island; 2 on Sunshine Coast of BC mainland).	Inspection of ACOs	1,820 ACOs	12,940	Ovaska and Sopuck, surveys for Western Forest Products
2006 (summer & fall)	21 sites in Pacific Rim National Park Reserve	Time-constrained daytime & night surveys; inspection of ACOs	96.9 person-hrs; 240 ACOs	960	Ovaska and Sopuck, surveys for Parks Canada
2006-2012 (mostly fall)	35 sites in the CRD on southern tip of Vancouver Island (public and private lands)	Inspection of ACOs (deployed in both transects and intensive grids)	2,473 ACOs	9,893	4 reports by Ovaska and Sopuck for Capital Regional District (CRD) Parks; 3 reports for Habitat Acquisition Trust (2010-12 only)
2007- 2009 (spring & fall)	6 sites on southern tip of Vancouver Island	Inspection of ACOs (deployed in both transects and intensive grids)	1,600 ACOs	7,780	Federal land surveys: 2 reports by Ovaska and Sopuck for DND, NRC, & Parks Canada in 2007, 2008 (IRF funds) and DND only in 2009
2006 (Spring: March only)	31 sites on Lower Mainland, Chilliwack Valley, Hope area; 4 sites on southern Vancouver Island	Time-constrained surveys	43.9 person-hrs	n/a	Ovaska and Sopuck, surveys for BC Min. of Environment

Year (season)	Area & number of sites	Survey type*	Total search time or effort; no. of ACOs*	# of ACO checks	Source**
2006 (fall)	30 sites on southwest coast and south-central inland mountains of Vancouver Island	Time-constrained surveys	40.6 person-hrs	n/a	Ovaska and Sopuck, surveys for BC Min. of Environment
2008 (fall)	2 sites on Vancouver Island (Pacific Rim National Park Reserve and Mt. Arrowsmith Massif area)	Time-constrained daytime & night surveys	Approx. 10 person-hrs	n/a	Biolinx Environmental Research Ltd., surveys for Parks Canada
2008 (spring & fall)	13 sites on southeastern Vancouver Island; 4 sites on Sunshine Coast on BC Mainland	Time-constrained surveys	16.1 person-hrs on Vancouver Island and 4.2 on Sunshine Coast	n/a	Ovaska and Sopuck, surveys for Environment Canada
2010 (fall)	1 site on Lower Mainland (Matsqui area)	Transect surveys	16.0 person-hrs	n/a	Sopuck and Ovaska, surveys for Matsqui First Nations
2012 (late summer)	10 sites on Brooks Peninsula and Port Alice area (northwestern Vancouver Island)	Time-constrained surveys, inspection of ACOs	15.3 person-hrs; 20 ACOs	40	K. Ovaska and L. Sopuck, unpubl. data
2009 (spring)	1 site on Saturna Island	Time-constrained surveys	About 6-8 person-hrs	n/a	Sopuck and Ovaska, surveys for Parks Canada
2009-2011	1 site (15 plots) on Lower Mainland (Burns Bog)	Inspection of ACOs	300 ACOs	2,100	Ovaska, Sopuck, and Heron, surveys for BC Min. of Environment
2009-2011	54 sites on Lower Mainland and Sunshine Coast	Visual searches of natural cover	112 person-hrs	n/a	Bains *et al.*, Parkinson and Heron, J. Heron, unpubl. data, surveys for BC Min. of Environment
2012 (fall)	1 site (59 plots and 1 grid) at Observatory Hill on southern tip of Vancouver Island	Inspection of ACOs	308 ACOs	1,232	Biolinx Environmental Research Ltd. (unpubl. data)

*ACOs: artificial cover objects made of layers of cardboard, placed flush to ground & inspected for gastropods every 7-14 days; quadrat survey: 1 x 1 m randomly located areas searched thoroughly; transect survey: searches of natural cover within 1 m x 100 m (or variable-length) strips of uniform habitat; point survey: searches of natural cover within a 5 m radius, centred on an important habitat feature; time-constrained survey: searches of suitable habitat features within a uniform habitat type for a specified time period, ranging from 15-60 min; Night searches: time-constrained searches of the forest floor after dark using spotlights

**Detailed reports are available for each set of surveys, except where indicated as unpubl. data.

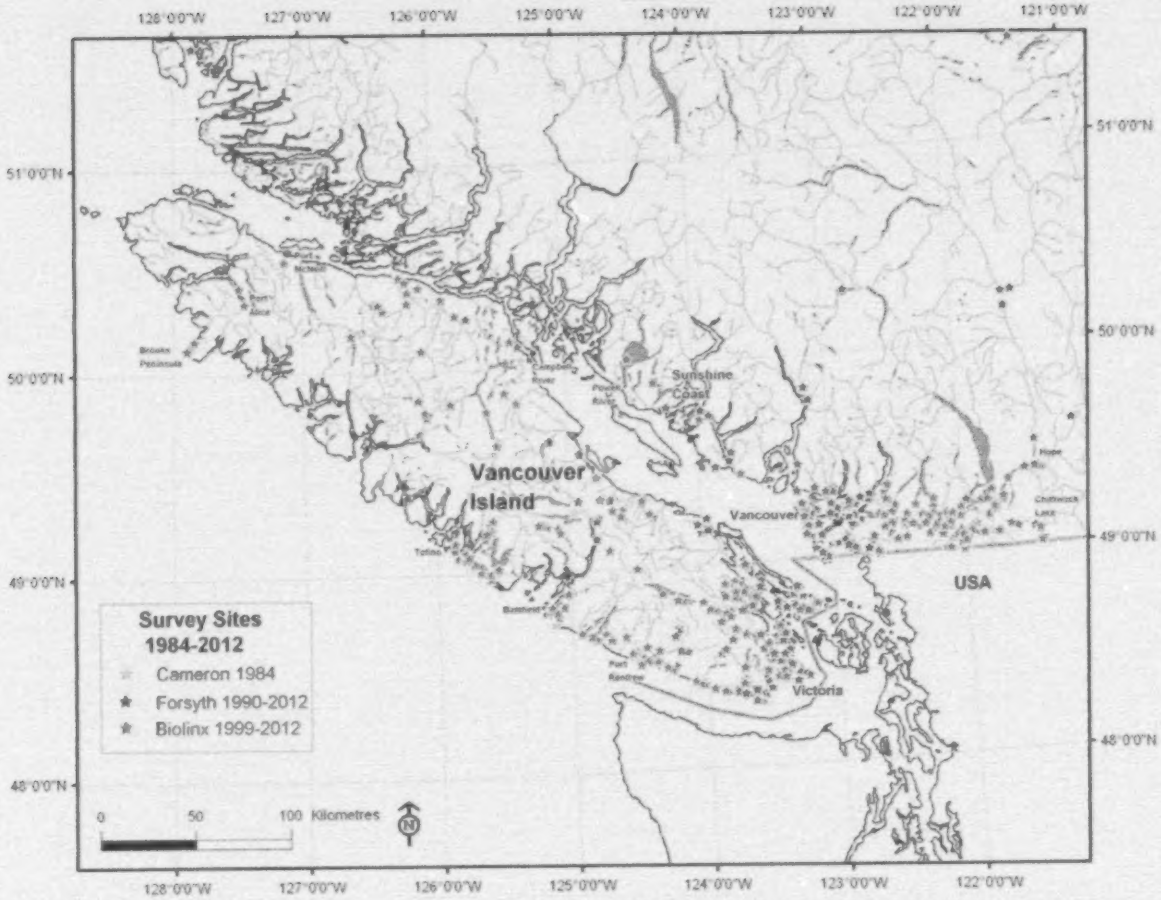

Figure 5. Overview of search effort for terrestrial gastropods in southwestern BC from 1984-2012. Surveys conducted from 1999-2012 by Biolinx Environmental Research Ltd. (Lennart Sopuck, Kristiina Ovaska, and co-workers), 1990-2012 by Robert Forsyth (personal files), and in 1984 by Cameron (1986). Map prepared by Biolinx Environmental Research Ltd. (L. Sopuck).

Searches for terrestrial gastropods have been carried out in forests of various ages on Vancouver Island. From 1999 – 2001, Ovaska and Sopuck (2005b) conducted surveys at 22 industrial forestry sites; most sites had both an uncut control and one or more variable-retention logging treatments. *Hemphillia dromedarius* was found only at one site, in an old-growth forest remnant. From 2000 – 2001, Ovaska *et al.* (2001) surveyed 104 sites on Vancouver Island, including 30 sites in younger (<80 year old) forests. The species was found at five old-growth forest sites. At one of these sites, the species was found in a remnant stand of old growth on top of a mountain, but not in the surrounding logged-over area. In 2003 – 2004, Ovaska and Sopuck (2004) surveyed 35 sites on Vancouver Island within the Capital Regional District and along the southwest coast of the island; 22 sites were in second-growth forest less than 80 years old. The species was not found at any of the sites. Younger forest has also been surveyed in Pacific Rim National Park Reserve, but the species has not been found in that habitat

(Ovaska and Sopuck 2005a, 2007a). In summary, over 800 sites have been surveyed for terrestrial gastropods in southwestern BC since 1984, involving a minimum search time of 1096 person-hours (search time not recorded for all surveys) and 38,500 artificial cover-object inspections (Table 3).

HABITAT

Habitat Requirements

On Vancouver Island, *H. dromedarius* occurs in moist, older coniferous forests (Table 2). Key habitat features are high humidity and a complex forest floor structure created by layers of decaying wood, root masses and crevices, such as is present in old-growth forests. However, the species is not restricted to old-growth stands but has also been found in moist mature forest (>80 years old). In mature and old-growth forests, a well developed canopy that provides shade, understory with moss mats, abundant coarse woody debris, and a complex forest floor structure are all thought to contribute to microhabitat conditions suitable for foraging, refuges, hibernation, and reproduction by the slugs (Parks Canada Agency 2012).

In BC, the majority of records for *H. dromedarius* are from the Coastal Western Hemlock (CWH) biogeoclimatic zone, which stretches in a broad band along the Pacific coast up to Alaska (Table 2; see Ministry of Forests and Range 2012 for a description of the biogeoclimatic ecosystem classification). This zone has one of Canada's wettest climates and supports productive temperate rainforests. Climate normals for Tofino, located within the species' core range along the Pacific Rim, show total annual precipitation of 3306 mm/year, average daily temperatures by month ranging from 4.5 °C in January to 14.8 °C in August, and high humidity throughout the year, especially at night (Appendix 2). At two sites where the slugs were found in the nearby Pacific Rim National Park Reserve, daily high temperatures ranged from 14.5 °C to 7.0 °C from mid-September to mid-December 2008, when night-time lows were above 0°C and suitable for slug activity (Ovaska unpubl. data 2008).

At higher elevations, *H. dromedarius* has been found in the Mountain Hemlock (MH) biogeoclimatic zone, which includes BC's coastal subalpine lands. The sites where the species has been found are within the lower portion of this zone, which is characterized by more dense, closed-canopy forests. In BC, the species has not been found in the upper portions of this zone, consisting of open parkland, heath, and meadow habitats. However, in Washington, it has been recorded from talus substrates in sparsely wooded subalpine habitats at several high-elevation sites at the eastern limits of its distribution on the east slope of the Cascade Mountains (Ovaska *et al.* 2002).

Parks Canada conducted habitat suitability modelling for *H. dromedarius*, based on habitat at known sites on Vancouver Island and expert opinion, which resulted in the development of a Baysian Belief Network Model for the species (Craig and Wilson 2008). Sites with the following habitat features were deemed optimal:

- fog/cloud layer present for all or much of the year, resulting in high humidity
- dense forest overstory
- cool or flat aspect
- minimum distance to forest edge of >100 m from the interior of forest
- forest type of Western Redcedar-Western Hemlock or Yellow-cedar-Mountain Hemlock
- forest structure classified as old (>140 years)
- topography classified as upland or a seep
- high abundance of large (>60 cm diameter), decayed (decay class 3-5) downed wood
- mor-type soils
- low level of soil contamination

Subsequently, in 2010, 11 known sites were visited as part of critical habitat identification. Habitat at and in the vicinity of the sites was characterized on the ground; orthophotos were used for four additional sites that could not be accessed (Parks Canada Agency 2012). Habitat almost always consisted of old forest and included nine different forest ecotypes (Table 2). Dominant trees were Western Hemlock (*Tsuga heterophylla*), Amabilis Fir (*Abies amabilis*), and Western Redcedar (*Thuja plicata*); Mountain Hemlock (*Tsuga mertensiana*) and Yellow Cedar (*Chamaecyparis nootkatensis*) occurred at some of the higher elevation sites. Along the Pacific Rim, *H. dromedarius* has not been found in the Sitka Spruce (*Picea sitchensis*) dominated fringe immediately adjacent to the coastline, despite considerable search effort (Ovaska and Sopuck 2005a, 2007a). Rather, along the coast, the species occurs farther inland beyond the spruce fringe within the Coastal Hemlock – Western Redcedar dominated forest. In Pacific Rim National Park Reserve, in addition to the spruce fringe, the species has not been found in other habitats that have been surveyed for terrestrial gastropods, including alder fringe (seral, riparian), bog forest, or immature coniferous forest (Ovaska and Sopuck 2005a, 2007a).

Sites where the slugs have been found have often been in remnant patches of old-growth forest (Table 2). The minimum size of habitat patches that can support populations over the long term is unknown, but a target of 20 ha was deemed suitable for critical habitat at occupied sites, based on considerations of edge effects in temperature and moisture regimes and the minimum size deemed sufficient to maintain a specific habitat type (Parks Canada Agency 2012). Of 15 delineated critical habitat polygons, three were significantly lower than this target value due to habitat

discontinuities (3 – 6 ha: Sites 2, 4 and 15 in Tables 1 and 2). At one site (Site 4 on Mount Brenton), only 3 ha of old-growth forest remained in the habitat patch occupied by the species, which was surrounded by logged areas.

In 2013, preliminary habitat suitability mapping was conducted based on the initial habitat model and results of the above site visits (Wilson and Craig 2013; Appendix 1). Two existing biophysical GIS base maps were used, each with its own advantages and limitations, which included the type of biophysical parameters and extent of coverage available: (1) Vegetation Resources Inventory, which is a polygon-based, photo-interpreted mapping standard used primarily by the forest industry to characterize vegetation (BC Ministry of Forests, Lands and Natural Resource Operations 2012), and (2) HectaresBC (2013) raster-based maps, used for a variety of ecological applications. Both approaches showed that the most suitable habitat is confined to narrow strips of land on the west coast of the island, with additional patches of generally lower suitability habitat farther inland (the areal extent was not calculated). The Vegetation Resources Inventory-based mapping resulted in the identification of more high suitability areas, while the HectaresBC-based mapping identified more but lower suitability habitat throughout the map area. Both maps, but particularly the HectaresBC map, overestimate the available habitat because landscape-level characteristics used may not have suitable site-level microhabitat features required by the slugs. However, the maps point out areas where further search and land management efforts can be directed. In particular, the mapping suggests that suitable habitat exists in the rugged areas north of Tofino on the west coast of Vancouver Island. However, this habitat is discontinuous and fragmented by a number of inlets and by logging. New records from this area are unlikely to significantly increase the EO or IAO.

Habitat Trends

Loss of older forest:

Forest habitats on Vancouver Island have undergone extensive loss and fragmentation since European colonization. At that time, about 70% of the land-base of the island was covered by old-growth forest. According to maps compiled by the Sierra Club (available at Ancient Forest Alliance 2009 – 2013), 21% of the forests were logged by 1954, 45% by 1972, and 71% by 1999. About 87% of the old-growth forest south of Barkley Sound, which contains records of *H. dromedarius* in remnant old-growth stands, has been logged (Ancient Forest Alliance 2009 – 2013). Forestry was initially confined to the southern and eastern portions of the island but has spread northward and westward. Further encroachment into intact forests, such as remaining old growth at higher elevations, is likely to continue in the future, due to economic pressures.

As part of a nesting habitat assessment for the Marbled Murrelet (*Brachyramphus marmoratus),* Long *et al.* (2010) quantified old-forest loss and modelled habitat recruitment over the 30-year period from 1978 – 2008 throughout coastal BC. Their most inclusive model (Model 3: forest age ≥140 yr; forest height ≥19.5 m; up to 50 km from ocean shorelines) showed that the greatest change had been on Vancouver Island with net loss of 25.8% of old forest in the west and north and 24.0% in the east of the island. Logging continues to diminish older forests on the island, with mature second growth and remaining old-growth being targeted. If the same rates are expected to continue, older forest can be predicted to continue to disappear at the rate of approximately 9% per decade along the west coast of Vancouver Island inhabited by *H. dromedarius.* Forest harvesting rates above 10% may occur in parts of this range, especially if valuable remnant old-growth is targeted disproportionably. In the Port Alberni operations area, which includes portions of Mount Arrowsmith Massif where *H. dromedarius* occurs, the planned forest harvest for 2013 is approximately 800 ha (Deal pers. comm. 2012). Assuming this annual rate for the next ten years, the rate of forest loss is 17% of the land base containing harvestable forest. Similar cut rates may also apply to other forest divisions, but because of the relatively large area and different land tenures (about half of the species' range is on private lands), it was not feasible to calculate rates of projected annual cut in more detail.

Climate change:

A warming trend in the world's climate is unequivocal, and changes consistent with climate change have already been documented (IPCC 2007). Elevated temperatures are accompanied by changes in precipitation patterns, and an increase in the frequency and intensity of extreme weather events is deemed "very likely" (IPCC 2007). As projected into the future, the warming will exceed that over the past 2000 years, but there is much uncertainty about the rate of change, and different scenarios have been proposed.

Overall, BC is predicted to experience greater than global average changes in temperature and precipitation (MFLNRO 2012). Increase in temperature is projected to be greater in northern than in southern parts of the province and least in coastal areas (see MFLNRO 2012 web site map Fig. A7). For Vancouver Island, increased summer temperatures are predicted, extending northward and westward on the island as climate change proceeds; in contrast, only a modest change in winter temperatures is predicted. Winters are predicted to become wetter across the province, while summers are predicted to become drier in central and southern BC but wetter in northern BC (see MFLNRO 2012 web site map Fig. A8). Increasing amounts of winter precipitation will fall as rain leading to reduced snowpacks, and snowmelt will occur earlier. There will be increasing demands on evaporative capacity of the atmosphere (MFLNRO 2012). For Vancouver Island, precipitation will decrease throughout the island in summer and increase modestly in winter.

Overall, the extent of the CWH biogeoclimatic zone is expected to increase with climate change, as a result of northward and upward expansion (Hamann and Wang 2006). The greatest expansion will occur within the present northern limits of this zone in mainland BC, where *H. dromedarius* is not found. Western Hemlock and Western Redcedar-dominated stands on the east and central Vancouver Island will most likely be replaced by drier Douglas-fir-dominated stands (Wilson and Hebda 2008). According to Royal BC Museum models, widespread decline for Western Redcedar in southern BC lowlands may start as early as 2020; die-back of Western Redcedars on parts of southeastern Vancouver Island have already been documented (Wilson and Hebda 2008). However, cool and moist oceanic portions of the CWH zone, including the west side of Vancouver Island, from where most records of *H. dromedarius* are from, and the central coast, are somewhat buffered by moderating influence of the ocean and are unlikely to experience stand-replacement level changes. Soil conditions, especially high organic matter content, may moderate the influence of climate change on ecosystems. Areas where soils are disturbed are likely to be particularly susceptible to loss of Western Hemlock-dominated ecosystems (Wilson and Hebda 2008).

The MH biogeoclimatic zone on Vancouver Island, occupied by *H. dromedarius* in the mountainous interior of the island, is a relatively recent ecosystem that has developed in response to cool and moist climates in higher elevations (Wilson and Hebda 2008). This zone is predicted to shrink rapidly under climate change scenarios both on Vancouver Island (Wilson and Hebda 2008) and throughout BC (Hamann and Wang 2006).

BIOLOGY

Life Cycle and Reproduction

Hemphillia dromedarius is a simultaneous hermaphrodite and lays eggs. Branson (1972) reported a clutch size of 50–60 eggs for Washington populations. The oval, semi-opaque eggs measured ca. 3.3 mm in length and 2.5 mm in diameter. Oviposition took place in wet or moist decaying wood. Nothing is known of the reproductive biology of the species in BC and no eggs have been found. Individuals on Vancouver Island live more than 1 year, based on the capture of mature individuals in spring.

Behaviour

Jumping-slugs derive their common name from their remarkable anti-predator behavior; the slugs typically exhibit "violent writhing and leaping" when disturbed (Pilsbry 1948: 738). This behaviour is well developed in *H. dromedarius* and can be elicited by handling. Presumably, it distracts potential predators, such as carnivorous snails, allowing the slug to escape unharmed. The species' secretive habits may also be an evolutionary response to predation pressure.

Physiology and Adaptability

The physiology of *H. dromedarius* has not been studied, but the slugs appear to require very moist conditions, based on habitats where they have been found. Climate normals for Tofino along the Pacific Rim show a consistently high average relative humidity throughout the year, especially during early morning (92 – 93% at 6:00 h; Appendix 2). The slugs are active on wet nights when the relative humidity is high and shelter within coarse woody debris or other retreats during dry ambient conditions. Moisture content in refuges is likely to be high. At one site, a slug was found late in the autumn, presumably at a hibernation site, buried deep within layers of saturated well-decayed wood (Ovaska and Sopuck 2000).

In BC, *H. dromedarius* is an inhabitant of older, coniferous forests and appears to require attributes of these forests. The degree to which it tolerates habitat disturbance is largely unknown. Isolated habitat patches from where the species becomes extirpated are unlikely to be repopulated through immigration.

Dispersal and Migration

Like other terrestrial gastropods, *H. dromedarius* is non-migratory, although seasonal shifts in habitat use may occur at a small scale within the movement capabilities of the slugs. Movements and dispersal for this species are unknown, but individual slugs have been found on the road surface of a 2-lane highway on rainy nights on two occasions (Beasley pers. comm. 2008; Sites 17 and 18 in Tables 1 and 2). Terrestrial gastropods in general are poor dispersers unless able to disperse by passive means such as wind or water or aided by animal vectors or human activities (Cordeiro 2004). No such means of dispersal are known or suspected for this species. Cordeiro (2004) considered distances of 1 km adequate to separate occurrences of terrestrial gastropods, both in continuous and discontinuous habitat, based on presumed dispersal capabilities of the animals.

Nutrition and Interspecific Interactions

The diet of *H. dromedarius* is incompletely known, but the slugs appear to feed heavily on fungi. There are several observations of the slugs feeding on mushrooms, both fresh and in advanced stages of decay, from Pacific Rim National Park Reserve (Ovaska and Sopuck 2005a, 2007a). In captivity, the species feeds sparingly on fresh vegetable matter; in contrast *H. malonei* and *H. glandulosa* readily consume these foods (Ovaska pers. obs.). Under natural conditions, the species may be a fungivore-detritivore. The availability of food as a limiting factor is unlikely, unless the species requires specialized food items (such as particular species of fungi or lichens) that are only present in certain forest types or ages.

A variety of vertebrates (birds, shrews, mice) and invertebrates (carabid beetles, carnivorous snails) may prey on *H. dromedarius*. Carnivorous snails on Vancouver Island include several widespread and abundant native forest species (*Haplotrema vancouverense*, *Ancotrema sportella* and *A. hybridum*). Numerous exotic species may also pose a problem for native gastropods through predation or competition for resources (Cameron 1986; Forsyth 1999, 2001), but few have been recorded from the Vancouver Island localities where *H. dromedarius* has been found.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Surveys that have included *H. dromedarius* as a target species have focused mainly on locating the species rather than obtaining abundance estimates (see **Search Effort**). Survey methods have included time- or area-constrained searches of natural cover, such as coarse woody debris or rocks, use of cardboard cover-objects, and visual searches of the forest floor after dark with spotlights (night searches). Daylight searches of natural cover and inspections of artificial cover objects were the most commonly used methods from 1984-2012 (Table 3).The species has been found with all these methods. Night searches have proven to be particularly effective, especially in coastal temperate rainforests, which are characterized by layers of large-diameter coarse woody debris that is difficult to search (Ovaska and Sopuck 2005a, 2007a).

Abundance

Little is known of population sizes, densities, or trends of *H. dromedarius* in BC. At the scattered sites where it occurs, the species appears to exist at very low densities. The number of individuals found per site usually ranged from one to two, even though considerable search effort was expended at each site (Table 4). The greatest number of *H. dromedarius* found during any one search consisted of eight slugs within an approximately 700 m-stretch of the West Coast Trail, Pacific Rim National Park Reserve, during 16.7 person-hours of search effort on the night of 21 – 22 June 2004 (Ovaska and Sopuck 2005a).

Table 4. Observations of *Hemphillia dromedarius* in relation to search effort, 2003 - 2006. Only surveys when the species was found are included.

Site ID	Site name	Date	Search type^	Search effort (person-hours)*	# of slugs
2	Mount Arrowsmith Massif, N slope of Mt. Cokely	21-Sep-06	Day	1.6	1
3	Mt. Arrowsmith, near McBey Creek	19-Sep-08	Day	2	1
4	Mt. Brenton, near Holycak Lake, ca. 18 km W of Chemainus	25-Aug-01	Day	2	2

Site ID	Site name	Date	Search type^	Search effort (person-hours)*	# of slugs
5	Mt. Hooper (near summit), ca. 20 km NW of Youbou	10-Sep-01	Day	1.7	2
6	Juan de Fuca Provincial Park: Loss Creek, near HWY14, SE of Port Renfrew	14-Apr-00	Day	1.5	1
6	Juan de Fuca Provincial Park: Loss Creek, near HWY14, SE of Port Renfrew	15-Jun-01	Day	0.7	1
7	Pacific Rim National Park Reserve, West Coast Trail unit: Thrasher Cove, NW of Port Renfrew	21 – 22 June-04	Night	16.7	8
9	Pacific Rim National Park Reserve, West Coast Trail unit: Keeha Beach Trail, near Cape Beale	20-Sep-06	Night	4.3	1
10	Bamfield, W of Woods End Landing	24-Jul-00	Day	1.0	1
12	Willowbrae, Ucluelet, adjacent to Pacific Rim National Park Reserve, Long Beach unit	20-Nov-06	Night	1.8	1
13	Indian Creek, ca. 9 km N of Ucluelet on Kennedy Flats	18-Nov-01	Day	9.0	1
14	Pacific Rim National Park Reserve (SE of Goldmine Trail)	27-Nov-03	Night	1.3	2
14	Pacific Rim National Park Reserve (SE of Goldmine Trail)	28-May-04	ACO	40 ACOs**	1
15	Pacific Rim National Park Reserve (Rainforest A Trail)	24-Sep-03	Night	3.5	2
15	Pacific Rim National Park Reserve (Rainforest A Trail)	28-May-04	Night	0.7	3
16	Pacific Rim National Park Reserve (Rainforest B Trail)	12-Jul-06	Night	4.9	1

^Day - Search of natural cover-objects (Coarse Woody Debris; rocks) during day; Night - Visual inspection of the forest floor with spot lights after dark; ACO - artificial cover-object survey using layered sheets of corrugated cardboard.

*Search effort - number of person-hours (h) spent searching per site when the species was found, or number of artificial cover-objects (ACOs) inspected.

**These cover-objects were inspected on 4 occasions in 2006 (160 cover-object flips) but only 1 *H. dromedarius* was found).

In comparison with other native species of forest slugs, *H. dromedarius* has been encountered infrequently even at sites where it is known to be present. At the stronghold of the species in Pacific Rim National Park Reserve, *H. dromedarius* comprised only 2.7% of 590 and 0.7% of 448 observations of native slugs found using four different survey methods in 2003 – 2004 and 2006, respectively. In contrast, *Ariolimax columbianus* (Pacific Bananaslug) comprised 77.3% and 83.5% and *Prophysaon foliolatum* (Yellow-bordered Taildropper) 19.2% and 13.2% of the observations in the two survey periods, respectively (Ovaska and Sopuck 2005a, 2007a).

Fluctuations and Trends

Continuing declines in populations are inferred and suspected based on shrinking old-growth forest habitat within the species' Canadian range on Vancouver Island. Based on trends in habitat loss from logging and additional projected habitat degradation due to droughts associated with climate change, populations are expected to continue to decline at a rate of 10% or more per decade (see **THREATS AND LIMITING FACTORS**).

All confirmed records from Vancouver Island are recent (1999–2008), precluding the examination of population trends from these data. However, surveys in 2001 revealed the presence of the species on Mt. Brenton, where it has persisted since 1916 based on Hanham's (1926) earlier, unconfirmed record. The area has been extensively logged since Hanham's observation. Within the logged landscape, the species (2 specimens) was found within a small, remnant patch of old growth. Searches in another remnant patch and in surrounding, regenerating forest were unsuccessful.

Population sizes and trends of *H. dromedarius* are poorly known in the US. Branson (1972, 1980) typically found 1-2 specimens of *H. dromedarius*/site: 8 sites in the Olympic Mountains (2 slugs from 2 sites; 1 slug from each of the remaining sites); 1977: 9 sites on the Olympic Peninsula (2 slugs/site from 2 sites; 1 slug at the remaining sites); 1980: 5 sites in the Washington Cascades (1 specimen/site at 4 sites; 2 individuals at 1 site). Although search effort is not known, these numbers suggest that *H. dromedarius* occurs at low densities in Washington as well as on Vancouver Island.

Population Fragmentation

Populations of *H. dromedarius* in the interior of Vancouver Island are isolated from each other and exist in remnant patches of older forest, where their viability is in question. The habitat along the West Coast of the island is more continuous but populations are restricted to relatively narrow bands (approximately 1 – 2 km wide) of old-growth and maturing forest, which abruptly changes to an extensively logged landscape to the east (inland). This narrow band of habitat may be of insufficient width to buffer the long-term effects of climate change and severe weather events. Also, the habitat quality of this band is often reduced by edge effects from nearby logged areas, roads, and other developments. Examples of narrow bands or patches of old-growth

forest occurring within fragmented landscapes can be found at three sites within Pacific Rim National Park Reserve (Sites 7, 15, 18), three sites immediately adjacent to the park (Sites 12, 17, 19), one site east of the park (Site 13), two sites near the town of Bamfield (Sites 10, 11) and one site south of Port Renfrew (Site 6; see Table 1 for site numbers).

Viability of *H. dromedarius* at each known site was assessed and rated as low, moderate, or high by the report writers based on threats, landscape context as assessed from GoogleEarth® orthophotos, and personal knowledge of the habitat on the ground. The assessment resulted in 58% of the 19 sites with a rating of low viability (11 low, 4 moderate, and 4 high viability; Table 2). Assuming that this pattern of known occurrences within fragmented landscapes applies to over half of the actual distribution of the species, then the population would meet the criteria for severe fragmentation, as per IUCN guidelines (i.e., >50% of the population is in habitat patches smaller than required for viability).

Rescue Effect

There is no possibility of rescue, because the range of *H. dromedarius* on Vancouver Island is separated by stretches of ocean from occupied habitats in the Olympic Peninsula on the US mainland. Should the species be found on the mainland of BC, a possibility of dispersal along the Cascade Mountains from Mount Baker National Forest would be plausible. However, because of poor dispersal capabilities of the slugs, rescue would be slow and limited to areas near the border.

THREATS AND LIMITING FACTORS

Restricted and patchy distribution, small area of occupancy, and the species' apparent reliance on old-growth forest or its attributes render *H. dromedarius* vulnerable within its Canadian range. Furthermore, subpopulations are probably becoming more isolated than historically as habitat is lost and fragmented, restricting gene flow and colonization of unoccupied habitats. In Canada, *H. dromedarius* occurs at the northern limit of the species' range, and as such may be particularly vulnerable to climatic fluctuations and stochastic events.

The IUCN threats calculator (Master *et al.* 2009) was applied to the species in November 2012 (Appendix 3). The scope of the threat was assessed based both on threats at occupied sites and their immediate vicinity and across the species' entire Canadian range, when the latter was considered relevant (see Appendix 4 for a list of threats at occupied sites). Focusing solely on the 19 occupied sites was deemed inappropriate, because additional undocumented sites may well exist. The overall threat impact was assessed as high, with 3 – 1 medium and 6 – 4 low impact threats (the range reflects uncertainty; Appendix 3). The threats deemed most important (in descending order) are discussed below.

Biological Resource Use (impact Medium)

Logging and wood harvesting

Logging continues to occur throughout the range of *H. dromedarius* on Vancouver Island (see **Habitat Trends**). The scope of this threat was assessed as restricted (11 – 30% of the population affected), based on the predicted amount of new logging taking place over the next ten years, as extrapolated from past rates of logging and available information on projected cut in one area within the species' range for which data were available. Only new logging was considered in the assessment, although previously logged landscapes may remain uninhabitable for the species for many decades.

Logging eliminates the moderating influence of the forest canopy, exposing the forest floor to sun and wind, so changing moisture and temperature regimes. These changes are expected to have negative effects on *H. dromedarius*, which is associated with very moist, cool conditions, such as prevail in old-growth coniferous forests. Logging also disturbs substrates and changes the structure of the forest floor, reducing the availability of suitable refuges for the slugs. Although younger forests may initially contain abundant coarse woody debris, there will be little new input, especially of large-diameter logs that are characteristic of *H. dromedarius* habitat, once the old-growth legacy of downed logs is gone. This change is gradual and will occur over a time-span greater than the next 10 years.

Edge effects resulting from logging are likely to extend far into the surrounding forest and may permeate throughout smaller reserves. A multi-year experimental study on the effects of variable retention logging practices in coastal British Columbia, including Vancouver Island, showed that smaller reserves (<2 ha) contained more depressed diversity and abundance of terrestrial gastropods after logging than did adjacent larger (>100 ha) habitat areas used as a reference (Ovaska and Sopuck 2008; *H. dromedarius* was not found within the experimental or reference sites). Small patches are subject to edge effects and degradation of microhabitats, thus rendering the slugs more vulnerable to both climatic fluctuations and natural predators. Even sites within protected areas may not be safe from edge effects, which could become more important during dry periods as climate change proceeds. In Germany, the diversity of forest-dependent slugs and snails was higher in forest patches greater than 700 ha than in patches less than 400 ha, and edge effects extended up to 250 m into the forest (Kappes *et al.* 2009). In addition, the number of forest-dependent species was positively associated with increasing forest age and amount of coarse woody debris (Kappes 2006; Moning and Mueller 2009). Similar results were obtained by Gotmark *et al.* (2008) in Sweden, who showed that species richness of slugs and snails was highest in landscapes containing least fragmented woodlands.

Google Earth® images show the extent of recent logging in the landscapes around known sites of *H. dromedarius* (Appendix 5). Logging is listed as a threat for 42% of the known sites (Appendix 4), but all known sites are already within landscapes fragmented or modified by logging.

Climate Change and Severe Weather (impact Medium – Low)

Severe weather and increased frequency of extreme events associated with climate change will affect all populations of *H. dromedarius* on Vancouver Island and are considered pervasive in scope (71 – 100% of population affected). The effects are likely to be greatest for the isolated populations in the interior of Vancouver Island, where broad-scale stand-level changes are predicted, including the replacement of Hemlock – Cedar stands with drier forest types (see **Habitat Trends**). There is much uncertainty about the speed of the changes, although some effects such as dying of Western Redcedars have already been documented in parts of Vancouver Island. The disappearance of *H. dromedarius* from much of the mountain habitats in the interior of the island is a plausible outcome over the next few decades as a result of drier conditions, exacerbated by habitat loss and alteration from logging. On the wetter west coast of the island, no stand-level changes are predicted with climate change. However, increased frequency and intensity of droughts and flooding events associated with climate change are likely to stress populations, leading to declines of unknown magnitude. Relatively low abundance, possibly reflecting declines, has been documented for terrestrial gastropods following prolonged droughts even after the return of suitable moist conditions in the autumn in Pacific Rim National Park Reserve (Ovaska and Sopuck 2007a; however, numbers of *H. dromedarius* in the samples were too low for conclusions) and the Capital Regional District (CRD) (Ovaska and Sopuck 2012; *H. dromedarius* has not been found in this area). Prolonged droughts during the activity period of the slugs from spring to autumn reduce time available for foraging and reproduction, even if refuges with moist microhabitats remain available deep within the forest floor. If such droughts occurred over multiple successive years, severe reductions in population size would be expected for this short-lived species. Conversely, severe flooding events when the slugs are concentrated in refuges due to drier conditions could lead to mass mortality.

Some species at risk may be particularly vulnerable to climate change because of their small population size, loss of unique habitats, and low reproduction or dispersal rates, leading to increased risk of extinction (Compass Resource Management 2007). These considerations apply to *H. dromedarius*, which has a patchy distribution particularly in the interior of Vancouver Island where populations exist in isolated habitat patches. Compass Resource Management (2007) summarized observed (documented) and projected impacts of climate change to BC's biodiversity. Most observed impacts linked to climate change have been in freshwater or marine environments. In the terrestrial environment, observed impacts include altered migration patterns of several bird species and loss of forest habitat to insect outbreaks, with increased air temperature as the primary driver. Predicted impacts are numerous as climate change proceeds. Impacts on sessile organisms with poor dispersal capabilities, such as many rare mosses, are predicted to be deleterious and severe, because they have no ability to escape adverse conditions by moving away to take advantage of possibly improved conditions elsewhere. Similar constraints apply to terrestrial gastropods in general and to *H. dromedarius* in particular, but with a few exceptions, such effects are unstudied and undocumented. In Bavaria, central

Europe, terrestrial gastropod diversity in high elevation sites was projected to increase as a result of climate change, but ranges of higher-elevation inhabitants were projected to shrink, resulting in an eventual extirpation of some species (Müller *et al.* 2009). In Switzerland, an upward elevational shift of 164 m in 95 years was observed for the land snail *Arianta arbustorum*, accompanying a 1.6°C rise in mean annual temperature during this period (Baur and Baur 2013). For *H. dromedarius*, interactions with new or more abundant predators and competitors spreading into its habitats may offset any potential benefits. Mechanisms for climate change impacts on BC species and ecosystems usually emphasize synergistic interactions with other stressors, such as habitat loss or invasive species (Compass Resource Management 2007).

Invasive and Other Problematic Species (impact Medium – Low)

Invasive non-native/alien species and problematic native species

Native species may be adversely affected by competition with introduced gastropods, which are prevalent in urban areas in BC, including Vancouver Island. Introduced species are expanding their ranges, and some have penetrated into forested areas (Forsyth 1999, 2001). Currently, few introduced gastropods have been found in habitats occupied by *H. dromedarius*; in particular, higher elevation sites in the interior of Vancouver Island appear to be devoid of introduced gastropods (Ovaska and Sopuck unpubl. data 1999 – 2010). However, introduced species may benefit from warmer conditions associated with climate change and, facilitated by increased human access through logging roads, expand their distributions to areas that are currently inhospitable but inhabited by *H. dromedarius*.

Native competitors, such as other slugs, and predators, such as carnivorous snails (*Haplotrema vancouverense* and *Ancotrema* species) and introduced carabid beetles (Carabidae), may also increase in abundance or expand their distributions into higher elevation habitats occupied by *H. dromedarius*, to the detriment of this species. Population characteristics (low densities) and behaviour (specialized escape behaviour; secretive habits) of *H. dromedarius* suggest that predation pressure has been important in shaping the evolutionary history of the species. In small habitat patches, in particular, concentration of invertebrate predators, such as carnivorous snails, may be detrimental for *H. dromedarius*, especially if suitable refuges are in short supply. Introduced gastropods were identified as a threat at 68% of the known sites (Appendix 4).

Residential and Commercial Developments (impact Low)

Housing and urban areas/ Tourism and recreation

New housing and recreational developments over the next 10 years are expected to be minor across the range of *H. dromedarius*, which is mostly on forestry lands. Of known sites, 3 – 4 sites will or might be affected by new housing or recreational developments (Appendix 4). There is a proposed campground development at one site and a resort development at another site along the Pacific Rim. The scope of this threat

was assessed as small (1 – 10%), but is likely to be closer to the minimum value of this range across the species' range. Habitat loss and modification associated with housing or intensive recreational developments are expected to have severe consequences to *H. dromedarius* populations. New housing may be built on the west coast of Vancouver Island between Sooke and Port Renfrew due to the removal of a large tract of privately owned forestry land from the Tree Farm Licence agreement in 2007 (Office of the Auditor General of British Columbia 2008). Some of this land has been bought by private forest companies and some has been added to the CRD Parks system. However, at least one large parcel has been bought by developers, and others are still for sale.

Transportation and Service Corridors (impact Low)

Roads and railroads

Logging roads are common over much of the range of *H. dromedarius* on Vancouver Island, and new roads are built to access areas slated for logging. The scope of the threat was rated as restricted – small (1 – 30%), reflecting uncertainties associated with logging road densities over the next 10 years and the extent of habitat loss and deterioration resulting from edge effects. Direct effects on the slugs are predicted to accrue from habitat loss due to construction of new roads, drying of the surrounding forest due to edge effects, and habitat fragmentation, rather than from roadkill. Edge effects of existing roads could increase with drier conditions as climate change proceeds, especially in higher elevation habitats in the interior of Vancouver Island. Drier conditions could also increase effectiveness of roads as barriers to movements of slugs, enhancing isolation and fragmentation of populations.

Human Intrusions and Disturbance (impact Low)

Recreational activities

Many known sites of *H. dromedarius* are subjected to recreational activities (Appendix 4). Although much of the species' range is remote, it is accessible along the networks of logging roads that continue to expand. The scope of this threat was restricted - small (1 – 30%). Severity of the effects on the slugs depends on the type of activity, ranging from high impact off-road all-terrain-vehicle use to negligible impact hiking. Two of the known sites in the interior of Vancouver Island are by fishing lakes and despite their remoteness receive relatively high recreational use. On a visit to one of the sites in 2010, the remnant patch of old-growth forest where *H. dromedarius* had been found in the past contained all-terrain-vehicle trails (Sopuck pers. obs. 2010).

Geological Events (impact Low)

Earthquakes/tsunamis / Avalanches/landslides

As currently understood, the best habitat for *H. dromedarius* on Vancouver Island occurs in moist low-elevation forests along the Pacific Rim, within a zone subject to tsunami warnings. Of the known sites, three are close to the shoreline and could be impacted by tsunamis. The scope of this threat was assessed as small (1 – 10%), and the timing as moderate – possible over the short term – reflecting the unpredictability of tsunami events.

Landslides are a regular occurrence in the mountains of Vancouver Island, exacerbated by roads and severe weather events. Because of their scope (<1% of population affected), their overall impact on the slugs is deemed negligible.

Number of Locations

Based on threats that could relatively rapidly affect all *H. dromedarius* within known occupied sites within a particular area, the number of locations ranges from 7 – 13, depending on the relative importance placed on the threats considered (Appendix 6). The higher values are probably more accurate, as the effects of severe weather, such as prolonged droughts, associated with climate change (which results in the lowest number of threats), are likely to become significant over longer time-spans than the next 10 years, especially for the populations on the wetter west coast of Vancouver Island.

If climate change and severe weather are considered the most important threat (Scenario 1 in Appendix 6), then there are seven locations. In this assessment, each mountain in the interior of Vancouver Island was considered a separate location, because the areas could be affected at different speeds and intensity based on the size of habitat patches, elevation, and amount of habitat fragmentation from logging. The occupied sites along the coast are in a more continuous and uniform habitat, but were divided into three locations based on geographic discontinuities and landscape context.

If logging is considered the main threat (Scenario 2 in Appendix 6), then each of the eight sites where logging is a direct threat (Sites 1, 2, 4, 5, 10, 13, and 17; Appendix 4) is a separate location. If for the remaining sites, climate change and severe weather is considered the main threat, then the number of locations is 11. If each site or nearby group of sites under the same management and land use is considered to be under a different threat (Scenario 3 in Appendix 6), then the number of locations is 13.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

COSEWIC assessed *H. dromedarius* as Threatened in 2003. In 2005, the species was listed as Threatened and placed on Schedule 1 under the *Species at Risk Act*. The British Columbia *Wildlife Act* prohibits the killing, capture, and harassment of all wildlife without a permit. Invertebrates are not considered wildlife under this act, but once appropriate regulations have been completed by the province, the *Act* will apply to *H. dromedarius* according to the 2004 Amendment to the *Wildlife Act*, which extends the coverage to all species designated federally as extirpated, endangered, or threatened.

Within parks and protected areas, the species is protected under the provincial *Park Act* (Juan de Fuca Provincial Park site) and the federal *Canada National Parks Act* (Pacific Rim National Park Reserve sites).

Non-Legal Status and Ranks

NatureServe (2012) assigned the status rank of G3G4 (vulnerable/apparently secure) for *H. dromedarius* globally, N2 (imperilled) nationally in Canada and N3N4 (vulnerable/apparently secure) nationally in US (ranks last reviewed in 2005). NatureServe's sub-national ranks for the species are S2 (imperilled) in BC and S3S4 (vulnerable/apparently secure) in Washington. NatureServe (2012) does not provide a ranking for Oregon, from where the species has been confirmed only recently. In BC, the species is on the red-list of species at risk and is ranked as Priority 2 for the provincial Conservation Framework (BC MoE 2012).

Habitat Protection and Ownership

About 6% of old-growth forest on Vancouver Island is protected within national or provincial parks. The largest parks within or adjacent to the range of *H. dromedarius* are the Pacific Rim National Park Reserve (49,962 ha), Carmanah-Walbran Provincial Park (16,450 ha), and Juan de Fuca Provincial Park (1,528 ha) (BC Parks 2012; Parks Canada website 2012). The species occurs along Loss Creek (formerly Loss Creek Provincial Park), which has been incorporated into the larger Juan de Fuca Provincial Park. The latter contains no significant stretches of old-growth forest, and how much of the habitat is suitable for *H. dromedarius* is uncertain; the species has been found in a remnant old-growth patch in the park. The Carmanah-Walbran Provincial Park contains the only significant stretches of continuous old-growth present on southern Vancouver Island, but to date the species has not been recorded from there. In the interior of Vancouver Island, the species occurs within Mt. Arrowsmith Regional Park (Alberni Clayoquot Regional District) (600 ha), which is contiguous with the larger Mt. Arrowsmith Massif Regional Park (Regional District of Nanaimo) (1300 ha). About one-quarter of Vancouver Island, the southeast portion, is mostly private land because of the Esquimalt and Nanaimo Land Grant in the late 1800s, which privatized all land within 20 miles of the Strait of Georgia from Victoria to Campbell River. Little old growth remains

on these lands, and logging regulations are generally less restrictive on private than on crown lands.

Hemphillia dromedarius has been found both in the Long Beach and West Coast Trail units of the Pacific Rim National Park Reserve, which appears to act as a stronghold and an important refuge for the species (Ovaska and Sopuck 2005a, 2007a). Landsat imagery shows that extensive logging has occurred across the landscape immediately adjacent to the park. On the west coast of Vancouver Island, suitable older forest habitat is limited to a narrow strip along the coast, much of which is within the Pacific Rim National Park Reserve, but this habitat also extends inland along major river valleys, such as the Carmanah and Walbran, where the species has not been found. The known occupied sites in the interior of Vancouver Island are on unprotected Crown or private forestry lands, with the exception of one site in Mt. Arrowsmith Regional Park.

On the west coast of Vancouver Island, the sites with records of *H. dromedarius* are on traditional territories of Pacheedaht, Ditidaht, Huu-ay-aht, Ucuelet, and Tla-o-qiuaht First Nations. Two sites are on Reserve lands of the Tla-o-qiuaht and Ucluelet First Nations, respectively (Vennesland pers. comm. 2012).

Critical habitat has been drafted for the species at 15 occupied sites (Table 2; Parks Canada Agency 2012), but federal approval is pending. If approved, habitat within the identified polygons and that is under federal ownership would receive protection from activities identified as damaging.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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COSEWIC Secretariat:
Sonia Schnobb
Jenny Wu
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Dave Fraser
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BC Conservation Data Centre:
Lea Gelling
Katrina Stipec

Additional contacts:
Barb Beasley, Biologist, Ucluelet, BC
Robert Forsyth, Research Associate, Royal BC Museum, Victoria, BC
William Leonard, Biologist, Olympia, Washington

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Kristiina Ovaska, Ph.D., M.Sc., received her doctoral degree in biology from the University of Victoria, after which she completed two post-doctoral studies in animal behaviour and population biology with McGill University and University of British Columbia, respectively. Presently, she is a partner in Biolinx Environmental Research Ltd. and research associate at the Department of Forest Sciences, University of British Columbia. Her experience with terrestrial gastropods includes research into effects of forestry practices, studies on patterns of abundance and distribution of species at risk, and numerous surveys in different parts of British Columbia, including Vancouver Island. She has prepared status reports, recovery strategies, a multi-species action plan, and best management practices guidelines for terrestrial gastropods. Her photographs of gastropods appeared in the Royal British Columbia Museum Handbook "Land Snails of British Columbia" by R. Forsyth. She is the author of more than 40 publications in the refereed scientific literature, including several papers on terrestrial gastropods.

Lennart Sopuck, M.Sc., RPBio, has studied a wide variety of wildlife species over the past 30 years. His expertise includes assessing and mitigating effects of various human activities on wildlife, including species at risk. Together with Dr. Ovaska, he is a

partner of Biolinx Environmental Research Ltd. and has conducted numerous survey and research projects on terrestrial gastropods of British Columbia, including searches for the Dromedary Jumping-slug. He is co-author of several status reports, recovery strategies, a multi-species action plan, and management documents for terrestrial gastropod species.

COLLECTIONS EXAMINED

No collections were examined for this report. Previously (COSEWIC 2003), the following institutional collections were consulted. Only the Royal British Columbia Museum holds specimens of *Hemphillia dromedarius* from British Columbia.

Canadian Museum of Nature [CMN], PO Box 3443, Stn. D, Ottawa, ON, Canada K1P 6P4.

The Field Museum of Natural History [FMNH], 1400 S. Lake Shore Drive, Chicago, IL, USA 60605-2496.

Royal British Columbia Museum [RBCM], 675 Belleville Street, Victoria, BC, Canada V8V 1X4.

Delaware Museum of Natural History [DMNH], 4840 Kennett Pike, PO Box 3937, Wilmington, DE, USA 19807-0937.

The Philadelphia Academy of Natural Sciences [ANSP], 1900 Benjamin Franklin Parkway, Philadephia, PA, USA 19103.

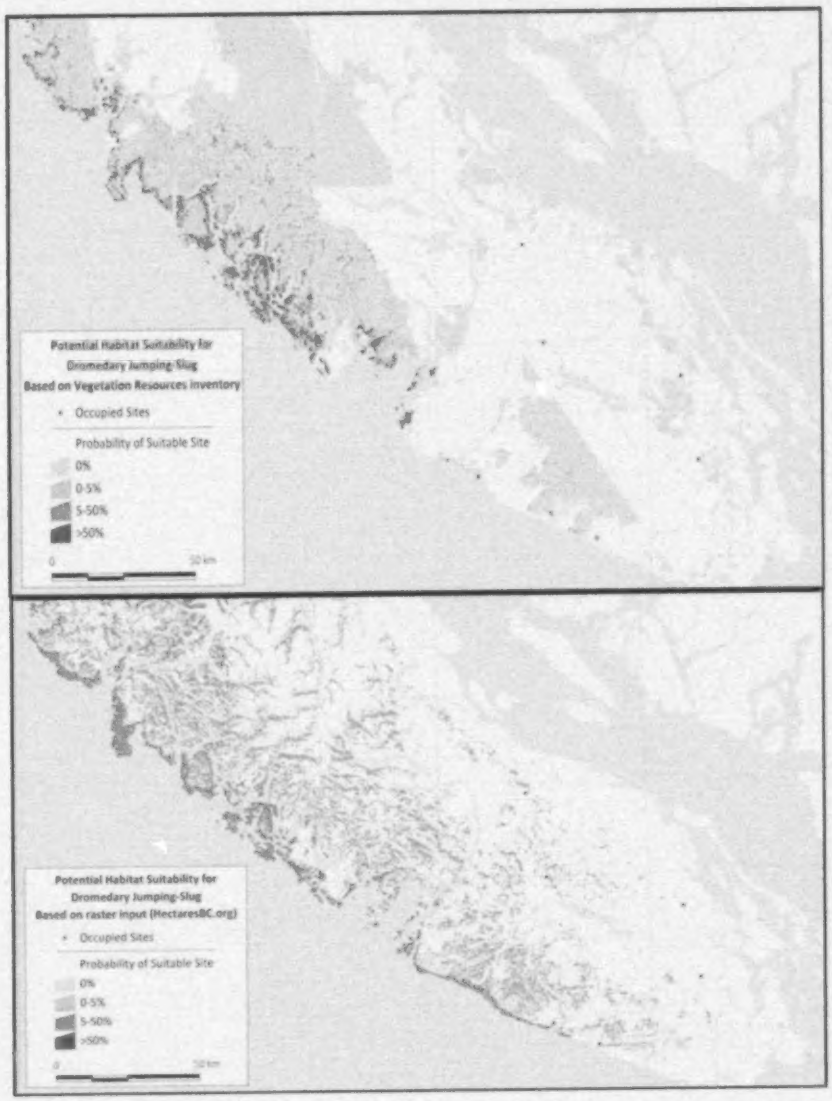
Royal Ontario Museum [ROM], 100 Queen's Park, Toronto, Ottawa, ON, Canada M5S 2G6.

Smithsonian Institution [NMNH], Washington, DC, USA 20560-0163.

Appendix 1. Preliminary habitat suitability mapping for the Dromedary Jumping-slug.

From: Wilson and Craig (2013, draft).

Distribution and abundance of potentially suitable Dromedary Jumping-slug habitat, based on the revised preliminary habitat suitability model and available Vegetation Resources Inventory data (top figure) and available raster data via HectaresBC (bottom figure).



Appendix 2. Climate normals (years 1971 – 2000) for selected weather variables recorded at Tofino weather station (data from Environment Canada 2012).

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (daily average (°C)	4.5	5.3	6	7.7	10.2	12.4	14.4	14.8	13.3	9.8	6.6	4.7	9.1
Temperature (Standard Deviation)	1.6	1.4	1.2	1	1	0.9	0.8	0.8	1	0.9	1.5	1.5	0.6
Precipitation (total; mm)	436	382	355	249	165	138	76.8	93.9	134	340.2	475	462	3306
Rainfall (no. days with ≥ 0.2 mm rain)	20.7	18.9	20.4	18.4	15.1	13.8	10.3	11	12.2	18.4	22.1	21	203
Degree days (above 5 °C)	31.8	34.6	45.8	82.5	162	223	291	302	249	148.3	63.8	34	1667
Relative Humidity - (average at 6:00 h; %)	91.7	91.2	91.7	92.2	92.9	93.5	94.9	96.2	95.5	95	91.8	91	93.1
Relative Humidity - (average at 15:00 h; %)	82	78	74.8	72.2	70.8	72.4	71.7	74.7	72.9	78.3	81.6	84	76.1

Appendix 3. Threats calculator results for *Hemphillia dromedarius* in Canada.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	*Hemphillia dromedarius*
Element ID	**Elcode**
Date (Ctrl + ";" for today's date):	2/11/2012
Assessor(s):	Dave Fraser, Dwayne Lepitzki, Kristiina Ovaska, Lennart Sopuck, Trudy Chatwin, Ross Vennesland, John Deal, Jenny Heron
References:	Recovery Strategy 2008

Overall Threat Impact Calculation Help:

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	3	1
D	Low	4	6
Calculated Overall Threat Impact:		High	High

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing
1	Residential & commercial development	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)
1.1	Housing & urban areas	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)
1.2	Commercial & industrial areas					
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)
2	Agriculture & aquaculture					
2.1	Annual & perennial non-timber crops					
2.2	Wood & pulp plantations					
2.3	Livestock farming & ranching					
2.4	Marine & freshwater aquaculture					
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
3.1	Oil & gas drilling					
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
3.3	Renewable energy					
4	Transportation & service corridors	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)
4.1	Roads & railroads	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)
4.2	Utility & service lines		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)
4.3	Shipping lanes					
4.4	Flight paths					

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing
5	Biological resource use	C	Medium	Restricted (11-30%)	Extreme (71-100%)	High (Continuing)
5.1	Hunting & collecting terrestrial animals					
5.2	Gathering terrestrial plants					
5.3	Logging & wood harvesting	C	Medium	Restricted - (11-30%)	Extreme (71-100%)	High (Continuing)
5.4	Fishing & harvesting aquatic resources					
6	Human intrusions & disturbance	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)
6.1	Recreational activities	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)
6.2	War, civil unrest & military exercises					
6.3	Work & other activities					
7	Natural system modifications		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
7.1	Fire & fire suppression		Negligible	Negligible (<1%)	Extreme (71-100%)	Low (Possibly in the long term, >10 yrs)
7.2	Dams & water management/use		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)
7.3	Other ecosystem modifications					
8	Invasive & other problematic species & genes	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)
8.1	Invasive non-native/alien species	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)
8.2	Problematic native species					
8.3	Introduced genetic material					
9	Pollution		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)
9.1	Household sewage & urban waste water					
9.2	Industrial & military effluents					
9.3	Agricultural & forestry effluents		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)
9.4	Garbage & solid waste					
9.5	Air-borne pollutants					
9.6	Excess energy					
10	Geological events	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High - Moderate
10.1	Volcanoes					
10.2	Earthquakes/tsunamis	D	Low	Small (1-10%)	Extreme (71-100%)	Moderate (Possibly in the short term, < 10 yrs)
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)
11	Climate change & severe weather	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)
11.1	Habitat shifting & alteration			Unknown	Unknown	Unknown

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing
11.2	Droughts	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)
11.3	Temperature extremes					
11.4	Storms & flooding	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)

Appendix 4. Threats at sites known to be occupied by *Hemphillia dromedarius* by Threats Calculator categories. Threat categories that do not apply to any sites are omitted.

X – threat present

Site ID	Site Name	1.1 Housing & urban areas	1.3 Tourism & recreation areas	4.1 Roads and railroads	5.3 Logging & wood harvesting	6.1 Recreational activities	6.3 Work & other activities	8.1 Invasive non-natives	9.3 Agricultural & forestry effluents	10.2 Earthquakes, tsunamis	11.1 Habitat shifting & alteration	11.2 Droughts	11.4 Storms and Flooding
1	7 km NW of Shawnigan Lake			X	X	X			X? (possible use of herbicides and/or fertilizers)		X	X	
2	Mount Arrowsmith Massif, N slope of Mt. Cokely			X	X (nearby, outside park boundary)	X (ATVs, climbers, hikers)					X	X	
3	Mt. Arrowsmith - near McBey Cr.			X	X (logging within few 100 metres)						X	X	
4	Mt. Brenton, near Holyoak Lake				X	X (ATV trails in forest patch)		X	X?		X	X	
5	Mt. Hooper (near summit)			X	X	X (by fishing lake)			X?		X	X	
6	Juan de Fuca Provincial Park: Loss Creek			X	No but logging very close	X		X				X	X
7	Pacific Rim NPR, West Coast Trail unit: Thrasher Cove				No but possible impacts through edge effects: of logging to the east 0.5-2 km away)	X						X	
8	Pacific Rim NPR, West Coast Trail unit: Clo-oose					X		X		X		X	X
9	Pacific Rim NPR, West Coast Trail unit: Keeha Beach Trail					X				X		X	X
10	Bamfield, W of Woods End Landing	X (new housing a possibility)		X	X			X		X		X	X
11	Bamfield Marine Station	X (new cabins a possibility)		X		X (mushroom picking, hiking)	X? (related to Marine Station)	X				X	
12	Willowbrae, Ucluelet		X (campground developed planned)	X (new roads being built)		X		X				X	

Site ID	Site Name	1.1 Housing & urban areas	1.3 Tourism & recreation areas	4.1 Roads and railroads	5.3 Logging & wood harvesting	6.1 Recreational activities	6.3 Work & other activities	8.1 Invasive non-natives	9.3 Agricultural & forestry effluents	10.2 Earthquakes, tsunamis	11.1 Habitat shifting & alteration	11.2 Droughts	11.4 Storms and Flooding
13	Indian Creek, ca. 9 km N of Ucluelet on Kennedy Flats			X	X			X	X?			X	X
14	Pacific Rim NPR (SE of Goldmine Trail)			X				X				X	
15	Pacific Rim NPR (Rainforest A Trail)			X	No but impacts possible through edge effects: logging 0.7km to north	X		X				X	
16	Pacific Rim NPR (Rainforest B Trail)					X		X				X	
17	Highway SE of Pacific Rim NPR border			X	X	X (mushroom picking)		X				X	
18	Highway right at the Pacific Rim NPR border			X	No but possible through edge effects in adjacent areas	X (mushroom picking?)		X				X	
19	Tyhistanis, near Pacific Rim NPR	X	X (resort planned or under development)	X				X				X	
	Total number of sites	3	2	14	8	14	1	13	4	3	5	19	5
	Percentage of sites	16	11	74	42.1	74	5	68.4	21	16	26	100	26

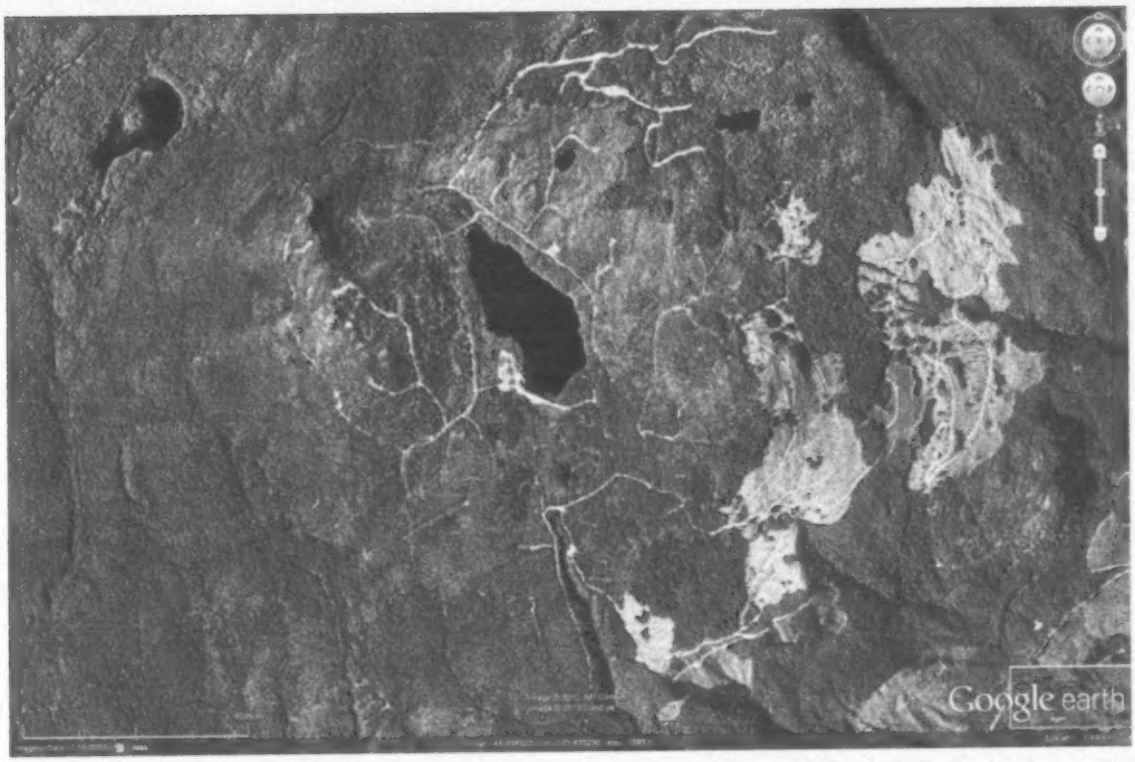
Appendix 5. Google Earth® images of the landscape in the vicinity of *Hemphillia dromedarius* observations, showing extent of habitat disturbance by forestry.

Pins point to approximate sites where the species has been found.

a) Site 1:

b) Sites 2 and 3:

c) Site 4:



d) Site 5:

e) Site 6:

f) Sites 7 and 8:

g) Sites 9, 10 and 11:

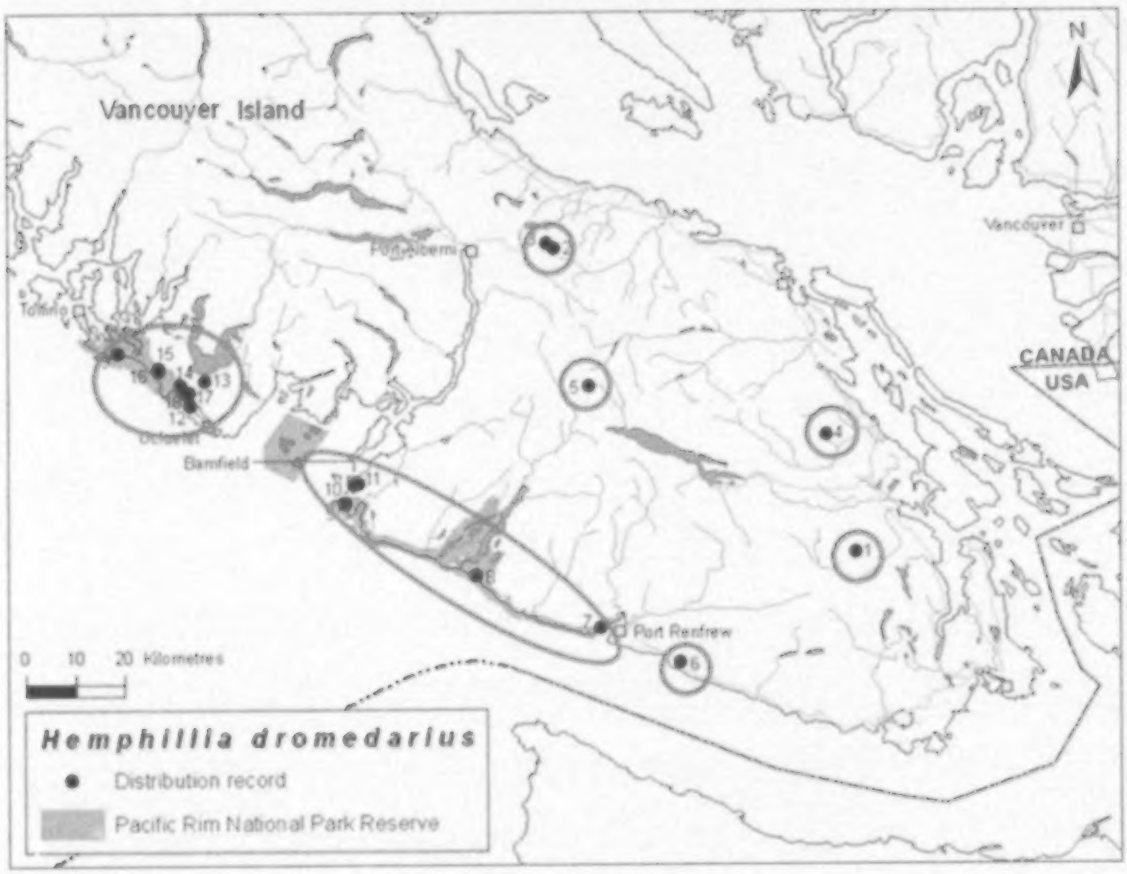
h) Sites 12-18:

Appendix 6. Sites occupied by *Hemphillia dromedarius* grouped by threat-based locations under different scenarios.

Scenario 1: Climate change and severe weather (droughts) are main threats at each site (7 locations); Scenario 2: Logging is main threat; climate change and severe weather (droughts) are main threats at remaining sites (11 locations); Scenario 3: Each site or group of nearby sites under same land ownership/management has individual threats (13 locations)

Location numbers refer to occupied sites that are grouped together under the same threat.

Site ID.	Site Name	Land Jurisdiction	Location - Scenario 1	Location - Scenario 2	Location - Scenario 3
1	7 km NW of Shawnigan Lake	Private forestry	1	1	1
2	Mount Arrowsmith Massif, N slope of Mt. Cokely	Crown land	2	2	2
3	Mt. Arrowsmith - near McBey Creek	Mt Arrowsmith Regional Park	2	3	3
4	Mt. Brenton, near Holyoak Lake, ca. 18 km W of Chemainus	Crown forestry Land	3	4	4
5	Mt. Hooper (near summit), ca. 20 km NW of Youbou	Private forestry	4	5	5
6	Juan de Fuca Provincial Park: Loss Creek	BC Parks	5	9	6
7	Pacific Rim NPR, West Coast Trail unit: Thrasher Cove, NW of Port Renfrew	Parks Canada; Federal	6	10	7
8	Pacific Rim NPR, West Coast Trail unit: Clo-oose	Parks Canada; Federal	6	10	7
9	Pacific Rim NPR, West Coast Trail unit: Keeha Beach Trail	Parks Canada; Federal	6	10	7
10	Bamfield, W of Woods End Landing	Private rural	6	6	8
11	Bamfield Marine Station	Private?	6	10	9
12	Willowbrae, Ucluelet, adjacent to Pacific Rim NPR, Long Beach unit	IR	7	11	10
13	Indian Creek, ca. 9 km N of Ucluelet on Kennedy Flats	Crown forestry	7	7	11
14	Pacific Rim NPR (SE of Goldmine Trail)	Parks Canada; Federal	7	11	7
15	Pacific Rim NPR (Rainforest A Trail)	Parks Canada; Federal	7	11	7
16	Pacific Rim NPR (Rainforest B Trail)	Parks Canada; Federal	7	11	7
17	Highway SE of the Pacific Rim NPR border	Crown land (Quarry?)	7	8	12
18	Highway right at the Pacific Rim National Park Reserve border	Parks Canada; Federal	7	11	7
19	Tyhistanis, near Pacific Rim NPR	Tla-o-qui-aht First Nation IR lands	7	11	13


Vancouver Island
N
Vancouver
Port Alberni
Tofino
CANADA
USA
Bamfield
Port Renfrew
0 10 20 Kilometres
Hemphillia dromedarius
Distribution record
Pacific Rim National Park Reserve